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UNCLASSIFIED

CORPS OF ENGINEERS, U. S. ARMY

TOPSOIL AND SEEDING STUDIES

AT

VICKSBURG, MISSISSIPPI

TECHNICAL MEMORANDUM NO. 3-354

PREPARED BY

WATERWAYS EXPERIMENT STATION

VICKSBURG, MISSISSIPPI

FOR

OFFICE OF THE CHIEF OF ENGINEERS

AIRFIELDS BRANCH
ENGINEERING DIVISION
MILITARY CONSTRUCTION

ARMY-MRC VICKSBURG MISS.

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Preface

During and since World War II, the Corps of Engineers has conducted turf investigations at various locations within the continental United States as part of a general airfields investigational program. The "Topsoil and Seeding Studies" described here were undertaken to augment previous turf investigations.

The studies were formulated at a conference in the Office of the Chief of Engineers on 14 December 1949 and were authorized in Instructions and Outline dated December 1949. They were conducted by the Soils Division of the Waterways Experiment Station at Vicksburg, Mississippi, during the period May 1950-May 1952. In addition to the field tests described here, a test section was constructed for the Waterways Experiment Station by the Engineering Experiment Station at Purdue University, Lafayette, Indiana. The results of the Purdue tests will be presented in a separate report to be published by the university.

Engineers of the Airfields Branch, Engineering Division, Military Construction, Office, Chief of Engineers, and Mr. E. B. Cale, agronomist and consultant, were active in planning the tests. Mr. Cale also participated in the field study and utilized information as it became available in preparing a general turf report for the Office, Chief of Engineers (not yet published). Engineers of the Waterways Experiment Station actively connected with the study were Messrs. W. J. Turnbull, C. R. Foster, O. B. Ray, and E. C. Meredith.

This report was prepared by Mr. Meredith.

fertilizer applied at three rates. Selected rows were left unfertilized for comparison. Observations and turf density ratings were made at monthly intervals and the plots were mowed as necessary.

Construction of Test Plots

Location of test site

3. The test site was located on the Waterways Experiment Station grounds at Vicksburg, Mississippi. The average precipitation in inches based on a 40-year record is as follows:

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
4.89	4.71	5.57	5.24	4.21	3.44	4.25	3.20	2.31	2.61	3.46	5.51

Annual, 49.40 in.

The average yearly temperature is about 65° F. The average for January is 50° F and for July is 81° F. The minimum temperature is -1° F occurring once every four years and the maximum is 104° F, reaching 100° F each year. The humidity is quite high, particularly in the summer months. Snowfall is rare and there are years when no measurable amount is recorded. The annual average snowfall is only 2.1 in., but occasionally it reaches a depth of 10 in. Snow seldom remains on the ground for any considerable length of time. In terms of precipitation, 1 in. of snow is considered the equivalent of 0.1 in. of rainfall. Killing frost occurs usually between 15 November and 18 March. The killing frost is seldom accompanied by frost penetration of measurable depth into the local soil and frost heaving is rare. There are on the average 252 days in the growing season annually.

4. An area for the test plots was selected that can be used for

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Introduction

1. The objectives sought in the tests discussed in this report were:

   a. To establish criteria for determination of suitability of soil for the production of turf grasses.

   b. To determine the relation of depth of topsoil to economy of establishment and maintenance of turf grasses.

   c. To determine the relationship of permeability of soil to economy of turf production.

   d. To determine economically effective seeding and fertilizing rates on various soils.

2. Three test plots utilizing different subgrades were built, as shown on plate 1, to accomplish the objectives listed above. Four types of soil were used, two rows of each type being placed in each plot. These soils are referred to as topsoils in the plan of test and throughout this report. However, it is pointed out that they are not topsoils in the normal meaning except for the fact that they were placed on prepared subsoils. Normally, topsoils have weathered over a period of years and contain a considerable amount of organic matter. Three of these four soils were of the granular type and the aggregate portion was obtained from the bed of a stream. They were "manufactured" by blending aggregate with either plastic or nonplastic fines. The fourth soil was from a natural formation but the surface material was stripped and material excavated to a depth of 3 ft. The soil rows were seeded at three rates and

fertilizer applied at three rates. Selected rows were left unfertilized for comparison. Observations and turf density ratings were made at monthly intervals and the plots were mowed as necessary.

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4. An area for the test plots was selected that can be used for

continuing general observations subsequent to the reporting of these tests. The area sloped in such a manner that the upper portion could be excavated and utilized for the plot having local lean-clay subgrade. The lower portion was utilized for the two plots having imported subgrades. The plots were arranged so that the two higher ones had uniform slopes of 3% downward to the south and the lower one had the same slope to the east. This arrangement made possible the provision of adequate over-all drainage for the area with a minimum distance of 15 ft between plots. Plate 1 shows the plan and sections for all plots. It may be noted that topsoil rows run east and west on plot 1 and north and south on plots 2 and 3.

Selection of soils

5. Review of existing literature and study of data collected by others indicate that the character of the subgrade, as well as composition of the topsoil, has a marked influence on the establishment and maintenance of turf. Findings and criteria for selection of soils adequate for growing turf grasses are included in the turf report prepared by Mr. E. B. Cale referenced in the preface to this report.

6. Three subgrade types were selected for use in these test plots: (1) impervious clay, (2) free-draining sand, and (3) lean clay. The impervious clay, commonly known as "buckshot," was obtained from the Mississippi River lowlands on the Mississippi side of the river just north of Vicksburg. The material was excavated from about 3 ft below original ground surface. The sand was a typical processed mortar sand from Bayou Pierre, at a location about 25 miles south of Vicksburg. The lean clay was native soil excavated from about 2 ft below the original ground surface and therefore free of vegetation. This native soil has been termed

clayey silt and loess in previous investigations. Under the current Unified Soil Classification System, the soil is a borderline case between inorganic clay and inorganic silt, having certain characteristics of both. The textural classification of lean clay is used throughout this report for the sake of clarity and consistency. Mechanical and chemical analyses of samples of each subgrade type taken after construction are given in table 1.

7. The following four soil types were selected for use as topsoils for placement over each subgrade type: (1) coarse-grained with nonplastic fines, (2) coarse-grained with plastic fines, (3) fine-grained plastic soil, and (4) well-graded silty sand. The two coarse-grained soils included creek-run sand and gravel. The nonplastic type was obtained by blending 75% of this creek-run gravel with 25% fine Mississippi River bar sand. The plastic type included 75% gravel and 25% friable clay from the Waterways Experiment Station Suboffice reservation at Clinton, Mississippi. The fine-grained plastic topsoil was the same impervious clay used as one of the three subgrade soils. The optimum-type soil was a combination of concrete sand, fine river-bar sand, and local lean clay blended in proportions that provided a well-graded lean sand clay. This soil compacted readily at the optimum water content. Thus, topsoils ranging from a coarse granular material containing almost no plant food to a heavy clay containing a supposedly large quantity of plant food were provided. Mechanical and chemical analyses of samples taken after blending and placement are included in table 1.

Subgrade construction

8. The entire test area was brought to the desired grade, 3% slope

in one direction and flat in the other as shown on plate 1, by excavating and wasting the material. Therefore, no compaction on existing soils was required. Shallow ditches were cut between and around the three test plots to provide over-all drainage and prevent water from running off of one plot onto another.

9. Sand subgrade. The free-draining sand subgrade was provided by placing a fill, composed of a commercially available mortar sand 1 ft thick, on the existing soil. Three tile drains were installed, as shown on plate 1, so that the sand subgrade would not retain water but would simulate a sand subgrade of greater thickness. Sections of tile (4 in. in diameter) were placed at a depth of 1 ft in the existing soil and back-filled with crushed limestone as illustrated in figure 1. The sand was transported to the site in trucks, dumped at the edge of each section, and pushed into place in thin layers with a D-4 tractor while it still retained a considerable amount of water. Compaction was provided by the tracks of the bulldozer. Training boards (1 in. thick) were used for outlining the topsoil rows. Where the specified topsoil thickness was 3 in., 3-in.-wide boards were placed on top of sub-grade. Where 6-in. topsoil thick-ness was specified, narrow trenches were dug, 6-in.-wide boards placed to final grade, and

Fig. 1. Tile underdrain, sand subgrade plot

Fig. 2. Sand subgrade plot before topsoiling

the excess sand between the boards removed by hand. Figure 2 shows the sand subgrade plot during placement of topsoil. Two of the clay topsoil rows shown in the photograph have been completed.

10. <u>Impervious clay subgrade.</u> Material for the impervious clay subgrade was hauled directly from the borrow pit to the site, spread in three layers and compacted with a D-8 tractor to a final thickness of 1 ft. This soil was quite lumpy (not friable) and full of roots and organic matter. The larger roots were removed by hand. Placement was completed before the large lumps dried. Training boards were placed in the same manner as described previously and the excess material in the 6-in. topsoil rows was removed with a bulldozer attached to a D-4 tractor. With considerable hand work, a reasonably smooth surface was provided on

Fig. 3. Impervious clay subgrade plot before topsoiling

which to place the topsoil. The impervious clay subgrade plot ready for topsoil placement is shown in figure 3. Sand subgrade placement may be observed in the background of this photograph.

11. Lean clay subgrade. The lean clay subgrade was provided by simply cutting into the existing soil at the high side of the test area. When the desired grade was obtained, training boards were placed in the same manner as on the other two plots, and excess material in the 6-in. topsoil rows was removed with a bulldozer attached to a D-4 tractor. Figure 4 shows the completed lean clay subgrade construction with the incompleted impervious clay and sand subgrade plots in the background.

Topsoil construction

12. All of the topsoils described in paragraph 7 were processed on

Fig. 4. Lean clay subgrade plot before topsoiling

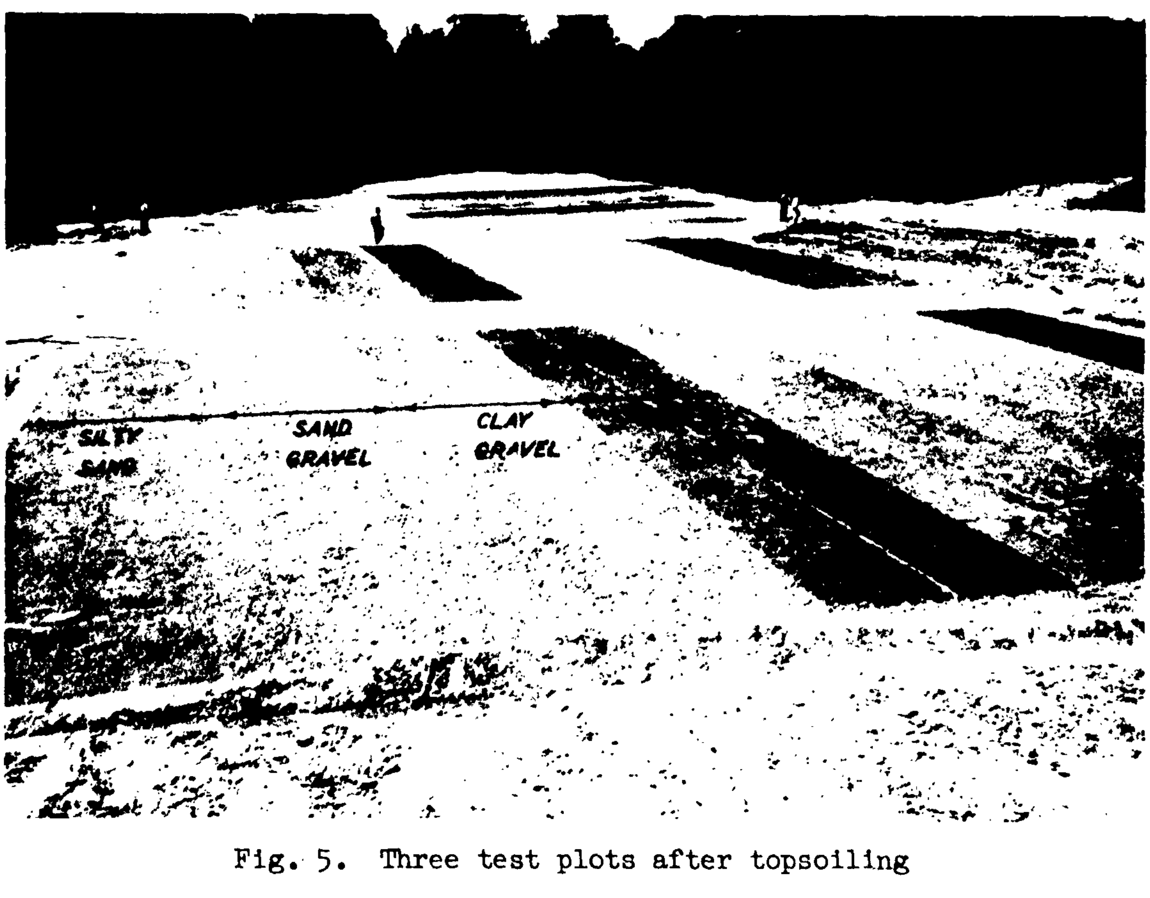

Fig. 5. Three test plots after topsoiling

an existing asphalt pavement near the test site where blending and pulverizing could be accomplished without contamination. Blending was accomplished by picking the soil up with a bucket loader and letting it fall back to the pavement. Three to four passes of the bucket loader were required to obtain a homogeneous mixture. In processing the impervious clay, the motor patrol spread the material in thin layers on the pavement so that it could be pulverized when picked up with the bucket loader. All topsoils were dumped into place from trucks, spread by hand and compacted with hand tamps. The rows were too narrow (5 ft) for use of heavy equipment either for placement or compaction. Steel pierced plank landing mat was placed on the sand subgrade so that trucks could maneuver. The same pattern of topsoil rows was used on each plot in duplicate. Figure 5 shows all three plots after placement of the topsoils, with topsoil type identified on the foreground plot. The topsoiling operations, including watering and raking to provide thin mulch at surface, were completed on 10 May 1950.

Fertilizer and seed treatment

13. The plan of test specified that all plots receive the same fertilizer and seed treatment and that the rows of fertilizer and seed be perpendicular to the topsoil rows as shown in plate 1. The fertilizer and seed treatments varied on the 12 rows as shown in plate 2. The specified unit of each of the three main elements (nitrogen, phosphorus and potash) in the fertilizer was one pound per 1,000 sq ft. The specified seed unit was 1.5 lb per 1,000 sq ft. Table 2 gives complete data as to the actual fertilizing and seeding of the plots, including subsequent applications of nitrogen to maintain turf density after establishment.

It may be noted that actual initial unit rates of fertilizer varied somewhat from the specified rates and were 1.6, 2.15 and 2.15 lb of nitrogen, phosphorus and potash, respectively. The higher than specified rates of phosphorus and potash resulted from use of locally available commercial fertilizer containing more of these two elements than of nitrogen. The unit rate of seed was 1.7 lb per 1,000 sq ft.

14. All plots were fertilized on 11 May 1950. A small spreader was used for application. Rows 1, 2, 3, 5, 6, 7, 9, 10, and 11 on each plot were treated with commercial 6-8-8 fertilizer at one level. Rows 4, 8 and 12 were left unfertilized. Two units of nitrogen were provided on rows 5, 6, and 7 by making a second application with nitrate of soda at a rate of 1.5 lb N for total of 3.1 lb N. Four units of nitrogen were provided on rows 9, 10 and 11 by making three applications of nitrate of soda or 4.5 lb N for total of 6.1 lb N.

15. The typical lawn grass formula selected for the tests by Mr. E. B. Cale, agronomist and consultant, was a blend of Kentucky 31 fescue and Bermuda. The fescue seed was applied at unit rate of 1.5 lb per 1,000 sq ft on 12 May 1950. These seeds were relatively large and spread readily through the spreader used. Bermuda seed was applied at unit rate of 0.2 lb on 15-16 May 1950. These hulled seeds were very small and were mixed with sawdust to enable application with the spreader at the desired rate. The rate and quantities of seed applied to the various fertilized rows are included in table 2. The scheme was to have variable seeding rates in each group of rows with a given fertilizer rate. Each of the two types of grass seed used was applied in sufficient quantity to provide a vegetative cover independently. It was contemplated that the

fescue would germinate first and that the Bermuda would require at least 30 days. Bermuda is the typical lawn grass used in the vicinity of Vicksburg, Mississippi.

16. Seed and fertilizer were raked into the soil after application of the seed. The treated topsoils were then rolled with a light hand roller (steel). A mulch of oat straw was spread uniformly over each plot at a rate of about 3 tons per acre (standard practice) and this mulch was anchored with twine. Figure 6 shows the completed test section just after placement of the straw mulch on 16 May 1950.

17. It is pointed out that fertilizing and seeding operations normally are accomplished in the spring, prior to 1 May, in the part of the country where these tests were conducted. However, a considerable

Fig. 6. Three test plots after fertilizing, seeding, and mulching

amount of rainy weather occurred during the period of construction, and the test plots were not ready for fertilizer and seed treatment until 11 May.

Turf Establishment, Maintenance, and Observations

18. Observations and pertinent data relative to establishment and maintenance of turf on the turf plots are presented by periods in chronological order for the sake of clarity. A summary analysis of the results is given subsequently. The duration of the period of observation was 2 years (May 1950 to May 1952). This period includes two growing seasons and two dormant winter seasons. A record of total rainfall and average daily temperature for the entire period is given in table 3. Frost penetration data are not included since such penetration was negligible and occurred only once for a brief period in February 1951. Precipitation was measured by a self-recording rain gage installed within a half mile of the test site for use in another study. Periodic ratings of turf density were made by visual observations using numbers from 1 (for excellent density) to 10 (for no turf). Accordingly, a rating of 9 indicated germination only and 5 indicated only fair density. Summaries of periodic density ratings given items in the sand, impervious clay, and lean clay subgrade plots are shown in tables 4, 5, and 6, respectively.

Period of seed germination

19. This period is considered to have begun on 16 May 1950 upon completion of fertilizer and seed treatment and extended to about the middle of July. This latter date, of course, extends into the establishment period since seed germination occurred at different times on different test items.

20. All plots were watered in the late afternoon three days after seeding, using a 3/4-in. hose and nozzle. The equivalent rainfall by this method of watering was less than 0.5 in. A total of only 0.6 in. of rain fell from time of seeding until the end of the month. The plots were watered again by the same method on 1 June. Rainfall totaled 2.7 in. during the first half of June and some of the seed germinated. The plots were given their first ratings on 12 June (see tables 4, 5 and 6). Germination was confined mainly to the clay topsoil rows. These rows also were infested with weeds and foreign grasses. Figure 7 shows the entire test section at time of rating but before mowing.

21. Dry weather was experienced again after 21 June (1.7 in. of rainfall on 20-21 June) until 6 July. The young turf in the 3-in. clay topsoil rows on the sand subgrade plots wilted on 15 June. Samples taken

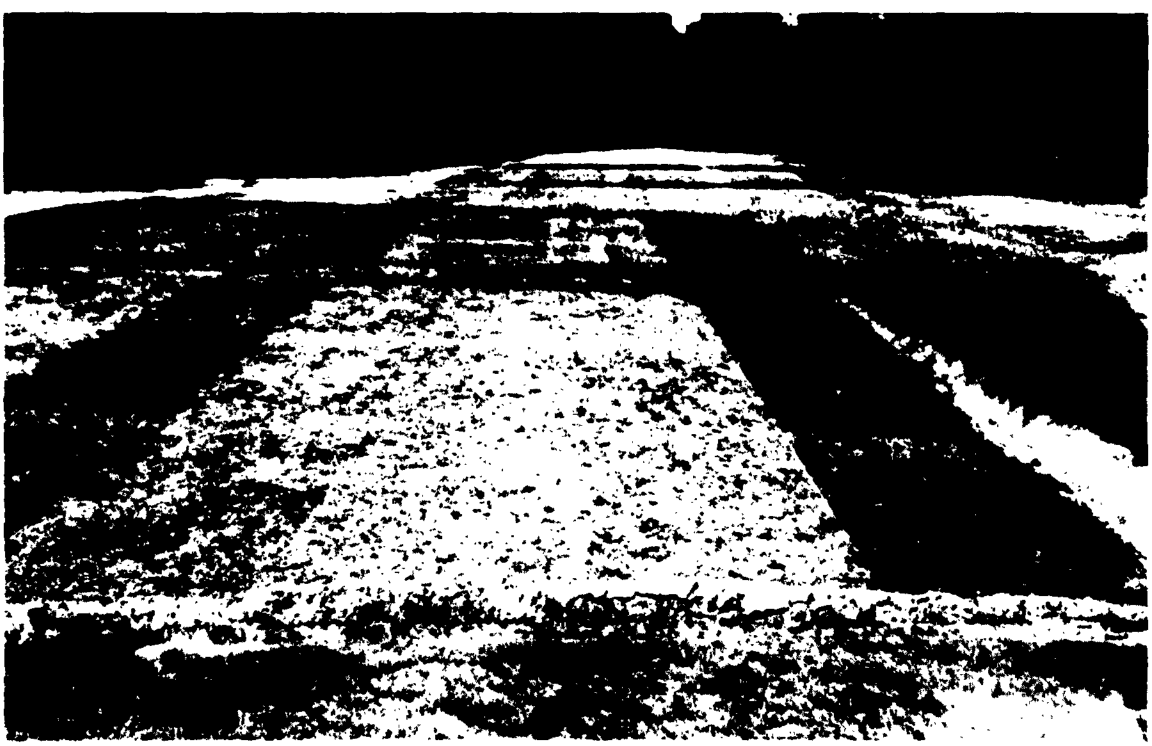

Fig. 7. Three test plots one month after fertilizing and seeding (12 June 1950)

from these topsoil rows in each plot showed that the water content was at or below the shrinkage limit of 25 in all cases, being as low as 14% in some instances. The young turf on the impervious clay and lean clay subgrade plots had not wilted, apparently receiving a supply of moisture from these fine-grained subsoils. Rather large and numerous shrinkage cracks had appeared in the clay topsoil rows.

22. Plots were soaked thoroughly on 15, 19, 26, and 30 June and 3 July. The 3/4-in. hose and nozzle were discarded and replaced with 1-1/2-in. fiber hose to which was attached a cloth sack to break the water pressure. The equivalent rainfall by this method was about 2.5 in. on clay topsoil and 1.5 in. on the pervious topsoils. All soils were soaked to full depth and until runoff occurred. The hose was placed at the upper side of the topsoil rows and water was allowed to flow down the 3% slope and soak into the topsoils. All plots were mowed as required to keep down the weeds and maintain the turf that had been established at a height of 1.5 in. Mowing at proper time intervals and not allowing the growth to become rank made it necessary to rake or remove the cut grass. Generally it was allowed to remain on the ground to form humus. Mention is made later in the report of difficulties resulting from both delay in mowing and cutting the grass too close.

23. The plots were rated on 30 June for the second time. The fescue seed had germinated since 12 June and the young plants had practically all died by 30 June because of the hot weather. In the meantime, germination of the Bermuda seed started. Ratings show that germination had taken place on most of the fertilized items but that turf density was spotty among comparable items. The improvement in items having 4 units of

nitrogen over those having 1 and 2 units was particularly noticeable. Turf density for a given item in the impervious clay topsoil rows was comparable in all three plots and, with one exception, was higher than in other topsoil rows. These rows continued to be infested with weeds. Density in the three granular topsoils on the sand subgrade plot was quite low. Turf was not too well established in the sand gravel and clay gravel topsoil rows on the impervious clay and lean clay subgrade plots. Greatest improvement was noted in the silty sand topsoil rows of the impervious clay subgrade plot where turf density was only one point less than excellent (rating of 2 in items having 4 units of nitrogen).

24. Mr. E. B. Cale visited the test site on 6-7 July. The plots were inspected on 7 July following a 0.8-in. rainfall on 6 July which helped the plots considerably. It was Mr. Cale's opinion that practically all seed germination that might be expected had taken place. He was not alarmed about the low turf density in numerous items after nearly two months and did not recommend reseeding. He agreed that Kentucky 31 fescue, when planted in late spring, was not a satisfactory lawn grass for this climate. Fall planting might have brought better results. His recommendations were that all fertilized rows be replenished with nitrogen and that artificial watering be discontinued except in case of extreme drought.

<u>Turf establishment period</u>

25. This period is considered to extend from 12 July to the end of the growing season in October 1950, although turf established concurrently with seed germination is not to be discounted. All plots were rated on 11 July and showed generally higher turf density than on 30 June; the main improvement being in the silty sand topsoil rows of the impervious clay

and lean clay subgrade plots where excellent ratings were given for items having 4 units of nitrogen. Turf density also increased considerably in clay gravel and sand gravel topsoils on these two plots.

26. Nitrogen was replenished on all fertilized rows at the uniform rate of 3.6 lb per 1,000 sq ft on 12 July. Nitrate of soda was used. Within one week, response was tremendous. The grass had taken on a dark green color and had grown vigorously to the point where mowing was required and the quantity of cut grass was such that raking was necessary to preclude smothering the young plants. The plots were rated on 22 July. Comparison of ratings with those for 11 July shows that increase in density on the sand subgrade plot was slight. On the other hand, density increased in all fertilized topsoil rows of the fine-grained subsoil plots, with numerous ratings of excellent being attained in that short period of 10 days. The greatest increases in density were in the clay gravel and sand gravel topsoils but the silty sand topsoil items had the larger number of excellent ratings. The marked difference in turf density among items originally treated with 1, 2, and 4 units of nitrogen was noted at this time.

27. During the next month (22 July to 22 August) the plots were mowed regularly. Growing conditions were good in that about 6 in. of rain fell intermittently up to 9 August. Dry weather after 9 August caused wilting on all topsoil rows of the sand subgrade plot. This plot was watered artificially on 15 August, reviving the turf temporarily. Turf ratings on 22 August show that inconsistencies between duplicate rows that had existed in the earlier part of the establishment period had been reduced to a minimum. Furthermore, turf had been substantially

established on all items other than nonfertilized rows within 3 months after seeding and about 1 month after complete seed germination. The straw mulch did not have to be removed as the turf became established because it disintegrated and was buried in the turf. Figure 8 shows the test plots on 22 August. The photograph was taken from about the same position as that of 12 June, figure 7.

Fig. 8. Three test plots three months after seeding (22 August 1950)

28. Several general trends had developed by 22 August. The local lean clay subgrade soil appeared to be somewhat superior to the impervious clay subgrade. The sand subgrade soil was definitely inferior. The grass grew faster and had to be mowed more often on the lean clay subgrade plot. Figure 9 is a side view of this plot just after mowing on 22 August. The three relatively barren nonfertilized rows may be noted. Rows originally treated with 4, 2, and 1 units of nitrogen appear at left, center and

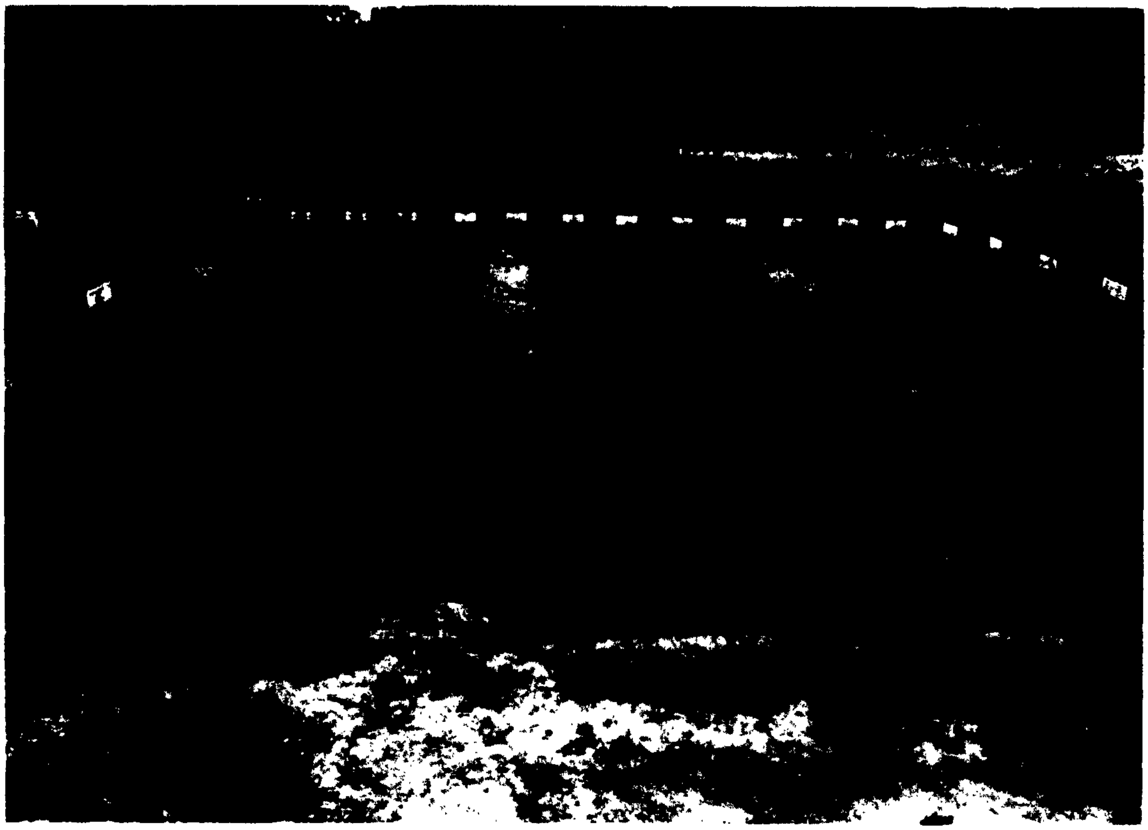

Fig. 9. Lean clay subgrade plot, three months after seeding (22 August 1950)

right of photograph, respectively. The amount of cut grass left by the rotary-type mower may be seen in the foreground. Figure 10 is a similar view of the impervious clay subgrade plot. Figure 11 shows the sand subgrade plot in the foreground. It can be seen that turf was fairly well established over free-draining sand even though turf density was not too high. The clay topsoil, initially the most productive type, had become the least satisfactory. The silty sand had the highest density, followed closely by the two gravelly soils. It was especially noted that when walking on the gravelly topsoil rows (about 2 in. maximum size aggregate) where turf density was high, the large aggregate could not be seen or felt under the feet. The 3-in. thickness of topsoil was somewhat

Fig. 10. Impervious clay subgrade plot, three months after seeding (22 August 1950)

Fig. 11. Free-draining sand subgrade plot, three months after seeding (22 August 1950)

superior to the 6-in. when the underlying soil had the greater water-holding capacity (impervious clay and lean clay subgrade), and the 6-in. thickness was definitely superior where the condition was reversed (free-draining sand subgrade). The fertilizer rate (nitrogen) had more effect on early establishment of turf than the seeding rate. Excellent turf densities had been reached at the lowest nitrogen rate in some of the silty sand and sand gravel topsoil items over fine-grained subgrade soils. Nonfertilized rows had not developed adequate turf density.

29. The next rating period was 22 August to 22 September. There was no rain from 9 to 29 August and the grass began to die again on the sand subgrade plot. Wilting occurred in the clay topsoil rows of the other two plots. These areas were watered whereas the other areas withstood the dry weather satisfactorily without watering. Plots were mowed four times. During one mowing some of the grass was inadvertently cut too close and took two weeks to revive. Growth was less rapid after 15 September. The grass on the sand subgrade plot turned brown between rains. Turf on the other two plots remained green. Ratings on 22 September showed that densities on the sand subgrade plot had begun to decrease. Most improvement was noted in the granular topsoil rows of the impervious clay subgrade plot. Ratings on this plot had become comparable to those on the lean clay subgrade plot.

30. The final rating period for the first growing season was 22 September to 22 October. No rainfall of any consequence occurred until 18 October. In the meantime, turf on the sand subgrade plot wilted badly even though the plot was watered artificially. Much of the Bermuda had died, the plot was infested with weeds and the soil was subject to erosion.

By 22 October all items were considered dormant and the first growing season was ended. No marked differences were noted in turf densities from those observed on 22 September.

31. At the end of this first growing season, plug samples were taken from representative items in each plot for the purpose of determining root penetration in the layered system. It was found that roots had penetrated to a depth of about 7 in. in the two fine-grained subgrade plots. These roots were firm in clay topsoil. Figure 12 is a view of a plug sample from the 6-in. clay topsoil row on lean clay subgrade. It can be seen that the roots extend about 1 in. below the topsoil. The roots were somewhat thinner and more fibrous in the granular topsoils. Figure 13 shows a plug sample from the 3-in. sand gravel topsoil row on impervious clay subgrade. The roots in the top 3 in. of the specimen appear quite

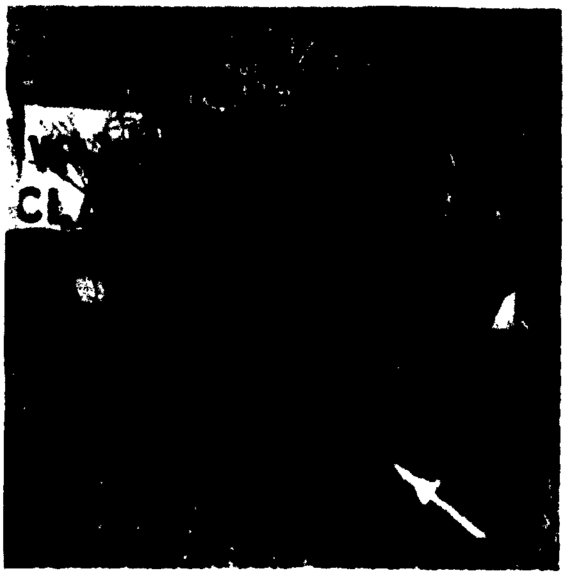

Fig. 12. Plot 3, October 1950. Profile of 6-in. clay topsoil with roots extending 1 in. into lean clay subgrade (roots firm throughout)

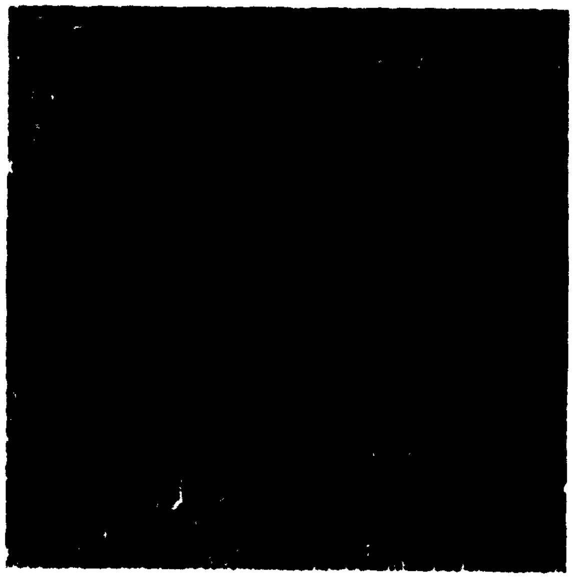

Fig. 13. Plot 2, October 1950. 3-in. sand gravel topsoil (note fibrous roots) with roots extending about 3 in. into impervious clay subgrade and becoming firm. Typical profile of granular soil on fine-grained subsoil

fibrous. As the roots penetrate into the clay subgrade they become firm again. The excellent stand of turf developed in this sand gravel soil may also be observed. The root system developed in the plot having a free-draining sand subgrade was not conducive to establishment of high turf density. The roots, with the exception of those in the clay topsoil, were extremely thin, fibrous, and irregular in length. In all cases they penetrated into the sand subgrade where the supply of moisture and plant food was very low.

Maintenance period

32. The maintenance period covered in this report is considered to extend from October 1950 through April 1952. Maintenance work consisting of artificial watering, mowing, and replenishment of nitrogen during the seed germination and/or establishment period (June to October 1950) has been discussed in previous paragraphs and is not to be discounted in determination of over-all maintenance requirements.

33. No maintenance work was required on the plots from the end of the growing season through the dormant winter season of 1950-1951. Rainfall and mean temperature, recorded on sheets 3 and 4 of table 3, were about normal for the months of November and December and part of January. Late in January the temperature dropped to 32° F or below, and precipitation consisting of rain, sleet, and snow in that order totaled about 4 in. The cold weather (0° F minimum) continued into February but a snow cover precluded frost penetration in the turf plots. No detrimental effects were noted after this unusually severe weather.

34. Unseasonably warm weather set in about 25 February and continued to 11 March. During this period, turf in the rows originally

treated with 2 and 4 units of nitrogen on the fine-grained subgrade plots grew vigorously and became dark green in color. Figure 14 shows the lean

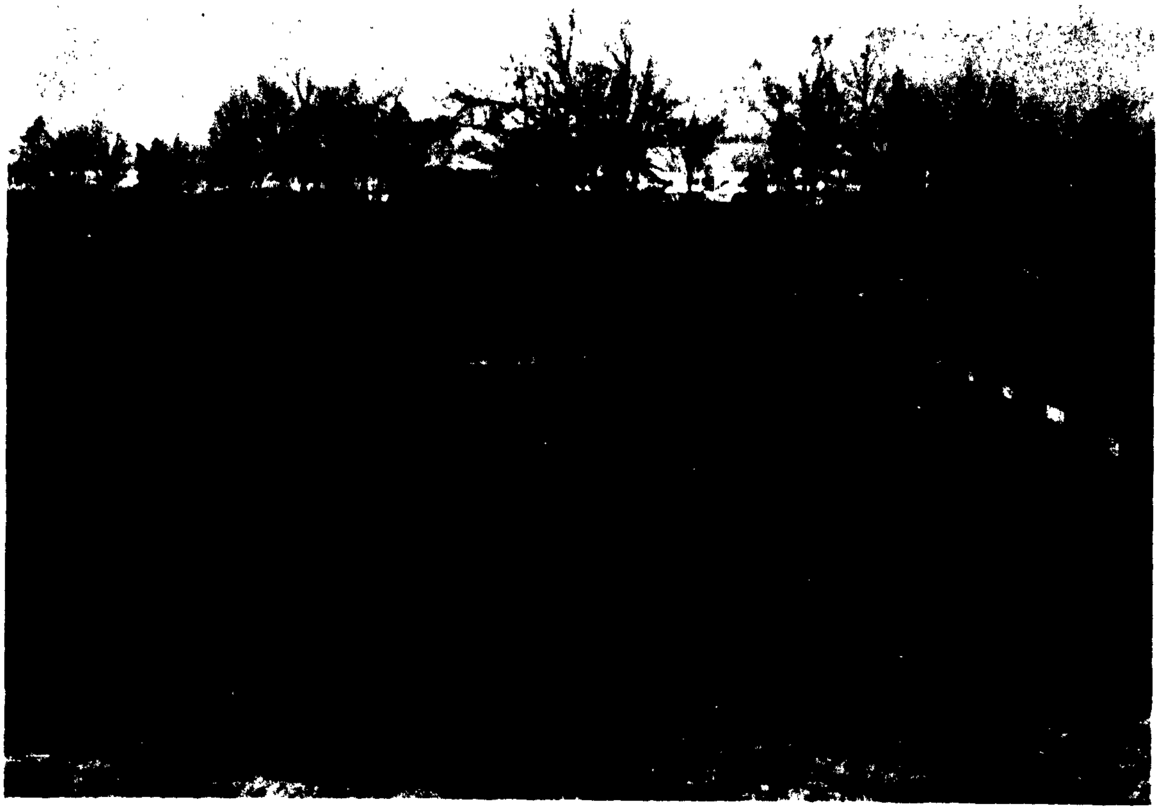

Fig. 14. Abnormal late winter growth in highly fertilized rows on lean clay subgrade plot (8 March 1951)

clay subgrade plot on 8 March 1951. The areas treated with 4, 2 and 1 units of nitrogen run from left to right on the photograph. There was no growth on the sand subgrade plot, the available nitrogen apparently having been expended during the previous growing season. The abnormal late winter growth was nullified as cooler weather returned later in March, and the grass turned brown again. It was considered and later substantiated that available nitrogen in the two clay subgrade plots was expended during this off-season growth.

35. Normal spring growth had not begun on 11 May. Weeds and

foreign grasses appeared in the sand subgrade plot and part of the impervious clay subgrade plot. Rainfall had been unusually light during the latter part of April and continued for the entire month of May. On 11 May, all fertilized rows were treated with 2.3 lb of nitrogen per 1,000 sq ft through the medium of ammonium nitrate. Response was good on the clay subgrade plots but nitrogen had little effect on the sand subgrade plot where the grass continued to die. Practically no rain fell until 9 June and the plots were not watered. However, the two fine-grained subgrade plots withstood this 48-day drought period very well. Turf became green and some growth was noted even though mowing was not required. Figure 15 is a general view of the test area at the end of the period of drought. The poor condition of the sand subgrade plot may be noted in the background

Fig. 15. Turf plots 30 days after replenishing nitrogen and 48 days after a good rain (10 June 1951)

of the photograph. Figure 16 is a close-up of the lean clay subgrade plot looking into the fertilized rows. The poor condition of the nonfertilized rows may be noted as well as the satisfactory condition of fertilized items. Growing conditions became more favorable after 9 June and regular mowings were required. The plots were rated on 17 July to compare turf densities on various items with those established the previous summer. Ratings for items on the impervious clay and lean clay subgrade plots were about the same as those for 1950. Clay topsoil rows showed some improvement but continued to be infested with weeds. Items on the sand subgrade plot had retrogressed considerably, aided to a great extent by the spring drought. At the end of this second growing season it was quite apparent that the nitrogen supply was again substantially depleted.

Fig. 16. Lean clay subgrade plot 30 days after replenishing nitrogen and 48 days after rain (10 June 1951)

36. The second winter was quite mild and had no detrimental effects on the established turf. There was a brief period of warm weather in late February 1952 just as in March 1951, but turf growth was less prominent since an equivalent supply of nitrogen was not available. The plots were treated with 5.0 lb of nitrogen per 1,000 sq ft on 15 April at constant rate on all fertilized rows. This rate was higher than desired due to mechanical difficulty with the spreader but less than the initial maximum rate which did not damage the younger plants. Spring growth to 15 April had been slight, probably due to abnormally dry weather. The entire area of the sand subgrade plot, as well as the nonfertilized rows of the two clay subgrade plots, had become infested with weeds. Where turf density was high, infiltration of weeds and foreign grasses had not become extensive. Where turf density was low, the areas were easily overrun with weeds that did not provide adequate vegetative cover the year around. By 30 April, spring growth of Bermuda was still limited but the fertilized rows in the two fine-grained subgrade plots had turned green as a result of the latest application of nitrogen. Response on the sand subgrade was negligible. After nearly two years of observations and maintenance, it is evident that nitrogen must be replenished on the manufactured topsoils used in these plots at least once a year to maintain high turf density. This statement applies to the plots on all three types of subgrade.

Summary and Analysis of Results

37. Extensive analyses could be made from the turf density ratings given in tables 4, 5, and 6, because of the large number of variables in these turf plots (288 items in duplicate). However, only five main

variables need be analyzed to determine trends applicable to the objectives listed in paragraph 1. They are effects of: (1) topsoil type, (2) subgrade type, (3) thickness of topsoil, (4) fertilizer rate, and (5) seeding rate. These effects are discussed where applicable in summarizing knowledge gained with respect to the five objectives of the study. Illustrations were selected so as to eliminate as many variables as possible. For example, the effect of topsoil type is shown for only the local lean clay subgrade plot treated with intermediate rates of fertilizer and seed.

Suitability of soil for production of turf grasses

38. A considerable portion of the work done in meeting the requirements of this objective consisted of review and analysis of data collected by others. Criteria were established for selection of suitable soils and are included in the turf report prepared by Mr. E. B. Cale (see Preface). Discussions in this report are confined to the specific soils used in the Waterways Experiment Station test plots.

39. The effect of topsoil type was quite noticeable during the first growing season on all subgrade plots. Plate 3 illustrates the trend of turf establishment with time on the local lean clay subgrade plot. Turf densities on rows treated with two units of nitrogen and seed (intermediate rate) are used. It can be seen that the clay topsoil rows developed turf first but that excellent turf density was not attained in all cases, even after careful maintenance through the second growing season. Previous mention has been made of the large shrinkage cracks that appeared during dry weather and the fact that the material was infested with weeds. Turf density ratings on well-fertilized items were quite good (2-3) and

would be adequate for many uses. The silty sand was second in establishment of turf and the first to develop excellent density. Sand gravel was third and clay gravel fourth, with the former having excellent turf rating three months after seeding whereas the latter required four months. All three of the granular topsoils maintained high density throughout the period of this study. Comparison of results of chemical analyses of the topsoils (tables 1 and 6) with performance in turf production shows that pH values as high as 8.4 were satisfactory and an organic content as low as 5% was adequate. Available supplies of phosphorus, calcium, and potassium were sufficient in all topsoils. This seems to account for the fact that only nitrogen had to be replenished in maintaining turf density. In these particular soils, available parts per million as low as 150, 900, and 250 for phosphorus, calcium, and potassium, respectively, were sufficient.

40. Plate 4 illustrates the effect of subgrade type. The curves shown are for 6-in. thickness of silty sand topsoil treated with 2 units of nitrogen and seed. Trends in turf establishment were comparable on the impervious clay and lean clay subgrade plots. In both cases, excellent density was reached within about 3 months after seeding and has been maintained throughout the period of this study. Turf on the sand subgrade plot was established in about the same period of time but high density was not attained. Furthermore, retrogression occurred during dry periods in the first growing season even though the plot was watered as required to preclude wilting. Retrogression continued through the second growing season. Comparison of results of chemical analyses of the subgrade soils (table 1) with turf production shows that the poor performance of the

free-draining sand may have been aided by the very low organic content of 1% and deficiency in calcium.

Effects of topsoil thickness

41. Topsoil thickness showed definite trends depending on whether the underlying subgrade was a fine- or coarse-grained soil. Plate 5 shows plots of turf density versus time for the 3- and 6-in. thicknesses of silty sand topsoil over each type subgrade. The other constants in this analysis are 2 units of seed and nitrogen. The most striking difference resulting from varying topsoil thickness was on the sand subgrade plot. It may be noted that the density for the 3-in. thickness increased very slowly after seed germination and never exceeded a rating of fair (rating of 5). The items having 6-in. thickness, on the other hand, attained a density rating of 5 quickly and by midsummer had ratings of 2-3. The 6-in. thickness in this case was not sufficient, however, as retrogression occurred from August to September and continued during the second growing season. The minimum thickness of a topsoil blanket required over a free-draining sand appears to be considerably more than 6 in. The thin fibrous roots that were found below the 6-in. blanket for a depth of 1 to 2 in. into the sand seem to indicate that the blanket should be more than 8 in. and probably 10 to 12 in. thick so that roots could draw plant food and water from the topsoil. A more logical approach to supporting turf over free-draining sand appears to be to blend blanket material containing a considerable amount of fines with the sand to a depth of 10 to 12 in. The resulting mixture should then have sufficient fines (minimum of 12% passing no. 200 sieve) and be of sufficient thickness to maintain a vegetative cover. The quantity of imported soil might even be less than that required

for a 6-in. blanket. The two density curves on plate 5 for silty sand topsoil over the local lean clay subgrade show that the 3-in. thickness was somewhat superior to 6 in. early in the first growing season. However, it may be noted that density on items of both thicknesses was excellent before that growing season ended and remained so during the second year. Where the subgrade is coarse-grained and free-draining, the maximum practicable thickness is needed. Where the subgrade is fine-grained and has a greater water-holding capacity and plant food supply than the proposed topsoil, topsoiling is not required. Usually, proper treatment of the existing fine-grained soil will suffice and be more economical. Experience in establishing and maintaining turf on the Waterways Experiment Station reservation has shown that the native lean clay soil is adequate when treated with nitrogen.

Effects of permeability of soil

42. The plan of test specified that the water percolation rate for each soil in place be determined. However, neither apparatus nor test procedure was agreed upon and this rate was not determined. It was decided to use the centrifuge moisture equivalent test in considering the effects of variable permeability. The centrifuge moisture equivalent (CME) of each soil used in the test plots is included in table 1. This equivalent is the amount of water, expressed as a percentage of the oven-dried weight of the material, retained by the soil which has first been saturated and then subjected to a force equal to 1,000 times the force of gravity for 1 hour. It may be noted that the CME for the four plastic soils is about the same, respectively, as the plastic limit of each. Comparison of soil performance with CME values shows that the sand with CME

of about 1 was too pervious for use as a subsoil over which 3- and 6-in. layers of satisfactory topsoil were used. A minimum CME requirement for subsoil cannot be established on the basis of these tests since the other two types had values in the order of 20-33 and were satisfactory. For the topsoils, CME values as low as 4 were satisfactory and 30 appeared to be slightly high. The maximum limit was not established but approaches 30. Values of 15-20 are known to be satisfactory as evidenced by performance of the clay gravel topsoil in the plots themselves and local lean clay soil on the Waterways Experiment Station reservation.

Effects of fertilizer and seeding rates

43. Variable fertilizer rates were confined to one element (nitrogen) and were utilized only in the initial treatment. Plate 6 shows plots of turf density versus time for items of silty sand topsoil (6-in. thickness) on lean clay subgrade treated with 1, 2, and 4 units of nitrogen and 2 units of seed. Plots of density on nonfertilized rows are omitted because some of the ratings were high and inconsistent owing to encroachment from rows on either side having high density (see encroachment in figure 9). However, density was generally low (5-8) in these rows. In following these curves, it should be remembered that nitrogen was replenished on all items at a uniform rate on 11 July 1950. On 30 June 1950, germination was taking place slowly and no differences among variable rates of N could be detected (turf ratings of 8 in silty sand topsoil). However, by 11 July turf density had increased considerably in all items and was best in the items having 4 units of N. By 22 July, after replenishment of N, the items initially having 4 units of N had attained a turf density rating of excellent whereas the items with 2 and 1 unit of N had

reached ratings of 2 and 4, respectively. By 22 August items initially treated with 2 and 4 units of N were both rated excellent whereas the items with 1 unit of N had not quite reached that high density. All items other than nonfertilized rows maintained their high ratings throughout the first and second growing seasons. Therefore, the trend regarding fertilizer rate (N) is that a high rate is advantageous to promote early turf growth, and replenishment at a normal rate of 1-2 lb N per 1,000 sq ft is adequate to promote and maintain high turf density. The late abnormal winter growth in 1951 (figure 14, paragraph 34), even though more than 6 months after the initial treatment, indicates that the high nitrogen rate was advantageous during the early stages after turf establishment.

44. Plate 7 gives plots of turf density versus time for variable seeding rates of 1, 2, and 4 units per 1,000 sq ft. The constants are 6-in. thickness of silty sand topsoil, lean clay subgrade, and 2 units of nitrogen. It may be noted from the plots that no trend developed with respect to seeding rate other than the fact that one unit of seed was about as good as four units. For example, ratings were 2-3 in all cases on 11 July and excellent (1) by 22 August. The same trend of ineffectiveness of higher than normal seeding rate was noted on nonfertilized rows. The final turf ratings in July 1951 on these rows of the silty sand topsoil over lean clay subgrade averaged about 7 (table 6) for each seeding rate.

General maintenance requirements

45. The maintenance requirements on these turf plots for the two-year period May 1950-May 1952 may be summarized briefly. The straw mulch placed after fertilizing and seeding to prevent erosion and protect the young plants during the establishment period did not have to be either

replenished or removed at a later date. Artificial watering during the establishment period was undertaken as required but proved less effective as turf density increased. Replenishment of nitrogen was considerably more effective and economical than watering in aiding turf to withstand long periods of dry weather. Replenishment of nitrogen on manufactured topsoils at least once a year was a necessary measure in maintenance of turf density. Replenishment of a complete fertilizer was not required on these particular soils. Mowing to a height of not less than 1-1/2 in. was undertaken as required. When the grass was allowed to grow too high, it tended to turn to seed. When the grass was cut too close, growth was retarded. When heavy amounts of cut grass were not removed after mowing, the turf underneath tended to die out from lack of air and light.

Conclusions

46. On the basis of the results of tests and observations on the Waterways Experiment Station turf plots the following conclusions are warranted.

- a. Granular topsoils suitable for stabilized base course work and containing a limited amount of fines (12% minus no. 200) were satisfactory for producing turf. Impervious clay topsoil developed turf first but was a little less satisfactory, being infested with weeds and subject to retrogression by wilting when large shrinkage cracks developed during dry weather. The range of topsoil types tested was not wide enough to establish limiting criteria for extremely fine-grained soils but indications are that a heavier clay than the one used in these tests would be less satisfactory.

- b. Very fine-grained soils (CH and ML classifications) were satisfactory when used as subsoils on which intermediate type topsoils were placed. A free-draining sand subsoil would not support turf produced in a satisfactory topsoil up to 6 in. in thickness. The entire test plot became

infested with weeds as turf density decreased. The Bermuda grass died and the soil was subject to erosion, particularly during the winter months.

c. The 3-in. thickness of granular topsoil over the two fine-grained subgrades produced excellent turf and establishment was somewhat faster than in the 6-in. thickness but in each case the fine-grained subgrade could have been treated so as to support turf without topsoiling. Grass roots penetrated into the subgrade in each case (7 in. in depth).

d. The 6-in. thickness of topsoil over free-draining sand subgrade was quite superior to the 3-in. thickness during the turf establishment period but not thick enough to support turf growth. Grass roots were thin, fibrous, and irregular in length, penetrating into the subgrade in all cases. Minimum required blanket thickness over the sand is considerably greater than 6 in. It appears more feasible to blend topsoil and porous sand to a depth of 10 tc 12 in. than to increase blanket thickness for supporting turf. The quantity of topsoil used should be sufficient to provide a minimum of 12% fines in the blend. For fine-grained topsoils, the quantity might be even less than that required for a 6-in. blanket.

e. Rather pervious topsoils (CME as low as 4) were capable of producing turf. The CME of 30 for the impervious clay topsoil appeared to be about the maximum allowable.

f. The type of fertilization required to produce turf depends on the available quantity of essential elements in the soil under consideration. All topsoils tested contained sufficient amounts of these elements other than nitrogen. The heavier initial application of nitrogen was more effective than the lighter application in early establishment of turf. However, application at the intermediate rate was quite satisfactory. Good turf density was not attained in any of the nonfertilized rows and they became infested with weeds. Nitrogen treatment was absolutely necessary in establishing and maintaining turf in manufactured topsoils.

g. The standard seeding rate for Bermuda (about 0.2 lb per 1,000 sq ft or 10 lb per acre) was about as effective as four times that amount when coupled with high fertility. No trend could be established for Kentucky 31 fescue since the grass died soon after germination, being unsatisfactory as a lawn grass in the Vicksburg, Mississippi, area when planted in the spring of the year.

h. The use of grain straw as a mulch to protect newly fertilized and seeded areas was quite satisfactory and

required no maintenance whatsoever.

i. Replenishment of nitrogen at least once a year at a normal rate was a minimum requirement in maintaining turf density on the soils used in these test sections.

j. Nitrogen treatment was more effective and economical for maintenance of turf during extended periods of dry weather than was artificial watering.

k. The only maintenance other than watering during the germination period and periodic replenishment of nitrogen was regular mowing during the growing seasons. When the grass was cut too close (to less than 1-1/2-in. height) growth was retarded. When the amount of cut grass was excessive, raking was required to preclude destruction of the grass from lack of light and air.

TABLES

Table 1

TOPSOIL AND SEEDING STUDIES
WATERWAYS EXPERIMENT STATION TEST PLOTS
VICKSBURG, MISSISSIPPI

SOIL DATA

Mechanical Analysis

Sample No.	Identification	Sieve Size .75 in.	No. 4	No. 10	No. 20	No. 40	No. 80	No. 100	No. 200	Liquid Limit	Plasticity Index	Centrifuge Moisture Equivalent	Corps of Engineers Soil Classification
1	Sand subsoil	100	100	100	90	32	2	0	0	--	NP	[illegible].92	SP
2	Impervious clay subsoil	100	100	100	100	99	98	97	96	67	41	32.34	CH
3	Lean clay subsoil	100	100	100	99	98	96	95	93	35	11	19.92	ML
4	Impervious clay topsoil	100	100	100	100	100	98	97	93	54	29	30.32	CH
5	Clay gravel topsoil	90	59	51	45	35	23	22	21	21	7	15.44	GM
6	Sand gravel topsoil	87	58	49	44	32	19	17	12	--	NP	3.63	GM
7	Sand clay topsoil	100	99	97	90	60	33	31	25	--	NP	4.94	SM

Chemical Analysis

Sample No.	pH	Organic Matter, %	Available Parts Per Million: Phosphorus	Calcium	Magnesium	Manganese	Potassium
1	7.7	1.1	182	65	3	1	649
2	6.8	13.7	195	4209	50	1	939
3	8.3	13.7	247	1528	49	1	999
4	6.3	12.8	234	3705	49	8	949
5	8.1	4.8	156	3819	43	4	839
6	8.4	8.5	182	2958	37	6	300
7	8.4	16.0	234	943	34	3	260

NOTES:
(1) Atterberg limits determined from minus 40 mesh material.
(2) CME determinations on minus 40 material.
(3) Organic determinations on minus 35 material and corrected for total sample.
(4) Available parts per million determined on minus 10 material and not corrected.

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Table 2

FERTILIZING AND SEEDING DATA

Row	Date	Fertilizer	Rate Per 1000 Sq Ft(Lb)	Rate of N	Rate of P_2O_5	Rate of Potash	Date	Seeding Mixture % by Wt	Seeding Mixture Type Seed	Rate Per 1000 Sq Ft(Lb)
1	11 May 1950	6-8-8	26.85	1.6	2.15	2.15	12 May 1950 15-16 May 1951	88 12	Ky. 31 fescue Bermuda	1.5 0.2
2	11 May 1950	6-8-8	26.85	1.6	2.15	2.15	12 May 1950 15-16 May 1951	88 12	Ky. 31 fescue Bermuda	3.0 0.4
3	11 May 1950	6-8-8	26.85	1.6	2.15	2.15	12 May 1950 15-16 May 1951	88 12	Ky. 31 fescue Bermuda	6.0 0.8
4	---	None	---	---	----	----	12 May 1950 15-16 May 1951	88 12	Ky. 31 fescue Bermuda	1.5 0.2
5	11 May 1950 11 May 1950	6-8-8 Nitrate of soda	26.85 9.30	1.6 1.5	2.15	2.15	12 May 1950 15-16 May 1951	88 12	Ky. 31 fescue Bermuda	1.5 0.2
6	11 May 1950	Nitrate of soda	9.30	1.5	2.15	2.15	12 May 1950 15-16 May 1951	88 12	Ky. 31 fescue Bermuda	3.0 0.4
7	11 May 1950	Nitrate of soda	9.30	1.5	2.15	2.15	12 May 1950 15-16 May 1951	88 12	Ky. 31 fescue Bermuda	6.0 0.8
8	---	None	---	---	----	----	12 May 1950 15-16 May 1951	88 12	Ky. 31 fescue Bermuda	3.0 0.4
9	11 May 1950 11 May 1950	6-8-8 Nitrate of soda	26.85 27.90	1.6 4.5	2.15	2.15	12 May 1950 15-16 May 1951	88 12	Ky. 31 fescue Bermuda	1.5 0.2
10	11 May 1950	Nitrate of soda	27.90	4.5	2.15	2.15	12 May 1950 15-16 May 1951	88 12	Ky. 31 fescue Bermuda	3.0 0.4
11	11 May 1950	Nitrate of soda	27.90	4.5	2.15	2.15	12 May 1950 15-16 May 1951	88 12	Ky. 31 fescue Bermuda	6.0 0.8
12	---	None	---	---	----	----	12 May 1950 15-16 May 1951	88 12	Ky. 31 fescue Bermuda	6.0 0.8

Notes: (1) Nitrogen replenished with nitrate of soda (16% N) on all fertilized rows at constant rate of 3.6 lb N on 12 July 1950.
(2) Nitrogen replenished with ammonium nitrate (33.5% N) on all fertilized rows at constant rate of 2.3 lb N on 11 May 1951.
(3) Nitrogen replenished with nitrate of soda (16% N) on all fertilized rows at constant rate of 5.0 lb N on 15 April 1952.

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Table 3

TEMPERATURE AND RAINFALL DATA

1 May 1950 to 1 May 1952

Date	Mean Temp.	Rain.	Date	Mean Temp.	Rain.	Date	Mean Temp.	Rain.
5-1-50	69	1.19	6-1-50	76	0.13	7-1-50	75	
2	69	0.78	2	76	0.65	2	79	
3	74		3	74	1.23	3	83	
4	78		4	67	0.04	4	82	
5	80		5	68		5	82	
6	79		6	70	0.30	6	80	0.76
7	77		7	74	0.33	7	77	
8	75		8	78		8	75	
9	75		9	81	0.03	9	80	
10	77		10	78		10	81	
11	77		11	77		11	80	0.01
12	76	0.20	12	79		12	78	
13	68	0.75	13	79		13	81	
14	73		14	81		14	77	0.46
15	71	0.68	15	81		15	80	
16	71		16	81		16	82	0.57
17	76		17	83		17	82	
18	76		18	82		18	84	
19	75	0.12	19	82		19	83	
20	71	0.02	20	79	0.25	20	83	
21	76		21	81	1.51	21	83	0.30
22	77		22	83		22	79	
23	79		23	82		23	81	
24	77		24	83		24	82	0.39
25	78		25	82		25	81	0.30
26	77		26	84		26	82	0.02
27	75	0.06	27	83		27	79	1.85
28	74	0.11	28	80		28	76	0.28
29	77		29	79		29	80	0.86
30	73	0.31	30	76		30	81	
31	78		--	--		31	82	
Average	75.1			78.7			80.3	
Total		4.22			4.47			5.80

Date	Mean Temp.	Rain.	Date	Mean Temp.	Rain.	Date	Mean Temp.	Rain.
8-1-50	84		9-1-50	78	0.29	10-1-50	74	
2	82	0.09	2	78	0.03	2	76	
3	80	0.15	3	80		3	74	
4	79		4	82		4	64	
5	73	0.32	5	75		5	61	
6	76	0.09	6	71		6	63	
7	76		7	67	0.01	7	70	
8	78		8	71		8	68	0.14
9	80	0.13	9	70		9	61	
10	79		10	74		10	62	
11	79		11	78	1.85	11	65	
12	81		12	78		12	63	
13	83		13	73	0.86	13	64	
14	83		14	73	0.03	14	66	
15	84		15	74		15	66	
16	84		16	76		16	70	
17	83		17	80		17	68	0.04
18	80		18	78		18	68	0.78
19	77		19	76	0.07	19	74	0.12
20	79		20	75		20	70	
21	73		21	74		21	69	0.02
22	75		22	68		22	71	0.20
23	81		23	64		23	69	
24	82		24	64		24	65	
25	83	0.01	25	65		25	67	
26	82		26	72		26	68	
27	80		27	73	0.05	27	68	
28	81		28	74		28	70	
29	80	0.46	29	71		29	72	
30	78	0.05	30	76		30	75	
31	78	0.42	--	--		31	70	
Average	79.8			73.6			68.1	
Total		1.72			3.19			1.30

Date	Mean Temp.	Rain.	Date	Mean Temp.	Rain.	Date	Mean Temp.	Rain.
11-1-50	65		12-1-50	69		1-1-51	47	0.80
2	69	1.56	2	66	0.30	2	61	0.94
3	54	1.34	3	48	0.46	3	51	0.80
4	41	0.03	4	43		4	47	
5	46		5	52	0.84	5	50	
6	56		6	32	0.14	6	52	0.77
7	65		7	26		7	32	
8	69		8	39	0.02	8	33	
9	58	0.01	9	44		9	39	
10	42		10	40		10	49	0.12
11	40		11	42		11	40	
12	45		12	47		12	52	0.35
13	52		13	46	0.14	13	64	
14	54		14	45	0.66	14	56	0.15
15	71		15	49		15	47	
16	57	0.04	16	44		16	45	
17	50		17	46		17	60	
18	55		18	33		18	62	0.07
19	66		19	38		19	65	
20	57	0.39	20	45		20	63	
21	49		21	45		21	43	
22	53		22	53		22	40	
23	58		23	57		23	52	
24	33	0.02	24	58		24	40	
25	31	0.04	25	56		25	34	
26	44		26	51	0.22	26	39	
27	48		27	31	0.06	27	56	
28	49		28	33	0.20	28	54	
29	47		29	37		29	31	0.93
30	64		30	37		30	22	0.50
--	--		31	42		31	25	2.74
Average	52.9			45.0			47.0	
Total		3.43			3.04			8.17

Date	Mean Temp.	Rain.	Date	Mean Temp.	Rain.	Date	Mean Temp.	Rain.
2-1-51	14		3-1-51	70		4-1-51	67	
2	10	0.25	2	71		2	56	0.02
3	14		3	70		3	46	
4	32		4	59	0.27	4	58	
5	42		5	64		5	62	0.02
6	51	1.27	6	70		6	62	0.04
7	35		7	69		7	60	0.54
8	37		8	64		8	58	
9	43	0.62	9	60		9	55	0.02
10	49		10	64		10	57	
11	54		11	63		11	53	0.17
12	63		12	46	0.23	12	49	
13	62		13	34		13	55	
14	61		14	43		14	57	
15	53	0.54	15	50		15	64	
16	45		16	59		16	50	0.02
17	50		17	68		17	49	
18	62		18	54	1.28	18	58	
19	66	0.42	19	43	0.32	19	65	0.49
20	63	0.23	20	47		20	69	
21	51		21	53		21	67	2.68
22	50		22	59		22	61	0.02
23	52		23	66	0.07	23	60	
24	55		24	55		24	62	
25	60		25	57		25	71	
26	70		26	60		26	68	
27	68		27	58	6.29	27	70	
28	71		28	66	2.13	28	71	
--	--		29	54		29	68	0.02
--	--		30	53		30	71	
--	--		31	61		--	--	
Average	49			58			61	
Total		3.33			10.59			4.04

Date	Mean Temp.	Rain.	Date	Mean Temp.	Rain.	Date	Mean Temp.	Rain.
5-1-51	75		6-1-51	77		7-1-51	73	0.86
2	70		2	78	0.30	2	75	0.58
3	73		3	78		3	78	
4	69		4	72	0.03	4	79	
5	64		5	72		5	80	
6	66	0.02	6	74		6	79	0.07
7	60	0.02	7	77		7	79	
8	63		8	78		8	78	
9	67	0.29	9	77	0.66	9	79	
10	72	0.23	10	75	0.87	10	78	
11	62		11	74	0.01	11	78	
12	60		12	76	0.06	12	79	
13	61		13	76		13	80	
14	65		14	74	0.61	14	78	
15	69		15	69		15	76	
16	68		16	75	0.39	16	79	
17	70		17	76		17	80	
18	71		18	77	0.34	18	79	
19	75	0.01	19	77	0.04	19	81	
20	74		20	79		20	81	
21	73		21	78		21	82	
22	73		22	77		22	82	0.12
23	64		23	77		23	78	0.48
24	65		24	79		24	76	0.02
25	71		25	81		25	78	0.11
26	74		26	80		26	80	
27	73		27	79		27	80	
28	71		28	79	0.32	28	77	2.64
29	76		29	77		29	77	
30	81		30	75		30	80	
31	79		--	--		31	80	
Average	70			76			79	
Total		0.57			3.63			4.88

Date	Mean Temp.	Rain.	Date	Mean Temp.	Rain.	Date	Mean Temp.	Rain.
8-1-51	78		9-1-51	84		10-1-51	74	
2	78		2	84		2	72	
3	81		3	82		3	72	
4	81		4	84	0.24	4	76	
5	78		5	81	0.01	5	75	
6	79		6	82		6	72	
7	84		7	80		7	59	0.03
8	84		8	77		8	52	
9	83		9	78		9	50	
10	83		10	74	0.46	10	51	
11	82		11	80		11	52	
12	80		12	80	0.10	12	55	
13	81		13	71	1.90	13	56	
14	80		14	68	0.02	14	59	
15	81		15	68		15	63	
16	82		16	68		16	64	
17	82		17	70		17	68	
18	78		18	66		18	66	
19	78		19	67		19	60	
20	82		20	70	0.13	20	60	
21	82	1.01	21	73	0.05	21	65	
22	78		22	76	0.51	22	70	
23	78		23	73		23	70	0.60
24	76		24	78	2.12	24	57	
25	78		25	76	0.04	25	56	
26	82		26	74		26	66	
27	83		27	74		27	69	
28	84		28	68		28	66	
29	85		29	65		29	62	
30	86		30	66		30	74	0.28
31	86		--	--		31	74	
Average	81			75			64	
Total		1.01			5.58			0.91

Table 3 (Continued)

Date	Mean Temp.	Rain.	Date	Mean Temp.	Rain.	Date	Mean Temp.	Rain.
11-1-51	42	0.13	12-1-51	50		1-1-52	73	
2	38		2	62		2	64	0.06
3	34	0.06	3	63	0.71	3	48	
4	44		4	58	0.32	4	55	0.70
5	54		5	60		5	42	
6	47	0.38	6	68		6	39	
7	36		7	67	1.29	7	42	
8	36		8	60	2.19	8	54	
9	42		9	44	0.28	9	57	0.22
10	50	0.15	10	40	0.04	10	41	
11	56		11	46		11	41	
12	60	0.01	12	50		12	55	
13	70		13	48		13	63	
14	64	0.47	14	50	0.80	14	67	
15	64	0.17	15	30		15	70	0.02
16	47		16	26		16	68	
17	34	0.01	17	38	0.08	17	66	
18	30		18	43	0.20	18	66	0.06
19	31		19	40	0.32	19	68	
20	36		20	56	0.40	20	61	0.30
21	46		21	37		21	60	
22	62		22	34		22	59	
23	64		23	47		23	43	
24	62		24	54		24	48	
25	63		25	62	0.14	25	60	
26	58	0.02	26	44		26	74	
27	45	0.43	27	36		27	56	1.90
28	40		28	44		28	48	
29	44		29	54		29	39	
30	42		30	67		30	44	
--	--		31	68		31	59	
Average	48			50			56	
Total		1.83			6.77			3.26

Table 3 (Continued)

Date	Mean Temp.	Rain.	Date	Mean Temp.	Rain.	Date	Mean Temp.	Rain.
2-1-52	59	1.04	3-1-52	46		4-1-52	63	
2	58		2	56		2	56	
3	62		3	65	0.60	3	55	0.20
4	51	0.22	4	47		4	55	0.35
5	46		5	44		5	46	
6	50		6	45		6	47	
7	51		7	50		7	59	
8	58		8	56		8	65	
9	63		9	59	0.11	9	63	
10	66		10	63	1.19	10	54	0.42
11	62	0.04	11	54		11	59	
12	65	0.46	12	59		12	56	0.90
13	71	0.05	13	63		13	55	
14	66	0.11	14	61		14	53	
15	53	0.43	15	48		15	49	
16	44	0.86	16	48		16	50	
17	45		17	51		17	52	
18	53		18	60	0.72	18	58	
19	63		19	67		19	57	
20	57	0.31	20	68		20	63	0.14
21	54		21	77		21	70	
22	51	0.64	22	60	0.89	22	67	
23	50	0.05	23	43		23	62	0.97
24	50		24	52		24	65	
25	48	0.22	25	56		25	56	
26	43	0.11	26	61		26	59	
27	53		27	59		27	57	
28	59		28	56		28	72	
29	65		29	61		29	75	
--	--		30	63	0.03	30	77	
--	--		31	67	0.03	--	--	
Average	56			57			59	
Total		4.57			3.57			2.98

Table 4

TURF PRODUCTION

Plot No. 1 - Sand Subgrade

Topsoil Type	Topsoil Thickness In.	Seeding Rate	Fertilizer (Nitrogen) Rate	Item Identification	Ratings 12 June 1950	30 June 1950	11 July 1950	22 July 1950	22 Aug 1950	22 Sept 1950	21 Oct 1950	17 July 1951
Impervious Clay	3	1	1	1 A-I	8-10	9-9	9-9	7-8	4-6	5-6	5-6	6-7
	6	1	1	1 B-J	8-9	9-8	8-8	7-8	4-4	5-4	5-4	5-7
	6	2	1	2 A-I	6-9	7-9	7-9	5-8	3-6	4-6	4-6	6-8
	3	2	1	2 B-J	6-9	7-7	7-7	5-6	3-4	4-4	4-4	5-8
	3	4	1	3 A-I	4-8	6-8	6-8	3-7	3-5	4-6	3-6	6-8
	6	4	1	3 B-J	4-8	6-7	6-7	3-6	3-4	4-4	3-5	5-8
	6	1	0	4 A-I	9-10	9-9	10-10	10-10	9-9	9-9	9-9	8-10
	3	1	0	4 B-J	9-10	9-9	9-9	10-10	9-9	9-9	9-9	9-9
	3	1	2	5 A-I	8-10	9-9	8-8	7-7	4-4	6-5	6-5	5-8
	6	1	2	5 B-J	8-10	8-8	8-8	7-7	4-4	6-4	6-4	6-8
	6	2	2	6 A-I	7-9	8-8	7-7	5-7	3-4	5-5	5-5	6-8
	3	2	2	6 B-J	7-9	7-7	7-6	5-6	3-4	5-4	5-4	7-7
	3	4	2	7 A-I	4-8	6-7	5-7	3-6	2-4	4-5	3-5	6-8
	6	4	2	7 B-J	4-7	5-4	5-5	3-4	2-4	4-5	4-4	7-7
	6	2	0	8 A-I	9-10	9-9	9-9	10-10	9-9	8-9	8-9	8-9
	3	2	0	8 B-J	9-10	8-8	9-9	10-9	9-9	9-9	9-9	9-8
	3	1	4	9 A-I	8-9	8-7	7-4	6-4	3-2	4-5	4-5	7-7
	6	1	4	9 B-J	8-9	7-6	7-4	6-4	3-2	4-4	4-4	6-8
	6	2	4	10 A-I	6-9	5-7	5-3	3-3	2-2	4-5	4-5	7-8
	3	2	4	10 B-J	6-9	4-5	5-3	3-3	2-2	3-4	4-4	7-8
	3	4	4	11 A-I	2-7	4-5	3-3	2-2	1-2	3-4	3-4	7-8
	6	4	4	11 B-J	2-8	2-4	2-3	2-2	1-2	2-3	3-3	7-8
	6	4	0	12 A-I	8-9	7-9	9-9	10-10	9-9	9-9	9-9	8-9
	3	4	0	12 B-J	8-9	7-8	8-8	10-9	9-9	9-9	9-9	9-8
Clay Gravel	3	1	1	1 C-K	10-10	9-10	9-9	9-9	4-5	4-4	5-4	6-6
	6	1	1	1 D-L	10-10	9-10	9-9	9-9	5-7	6-6	6-6	8-7
	6	2	1	2 C-K	10-10	9-10	9-9	8-8	3-5	4-4	4-4	7-6
	3	2	1	2 D-L	10-10	9-10	9-9	8-9	4-6	6-6	6-6	8-8
	3	4	1	3 C-K	9-10	9-10	9-9	7-7	3-3	4-4	4-4	7-7
	6	4	1	3 D-L	9-10	9-10	9-9	8-8	4-5	6-6	6-6	8-8
	6	1	0	4 C-K	10-10	10-10	10-10	10-9	9-9	9-9	9-9	9-10
	3	1	0	4 D-L	10-10	10-10	10-10	10-10	9-9	9-9	9-9	9-10
	3	1	2	5 C-K	10-10	9-10	9-9	9-9	4-5	4-4	4-4	6-7
	6	1	2	5 D-L	10-10	9-10	9-9	9-9	4-6	7-6	6-6	8-7
	6	2	2	6 C-K	10-10	9-9	9-9	8-8	3-3	4-4	4-4	7-6
	3	2	2	6 D-L	10-10	9-10	9-9	8-9	4-6	7-7	6-7	8-8
	3	4	2	7 C-K	9-9	9-9	9-9	7-8	2-2	4-4	4-4	7-8
	6	4	2	7 D-L	9-9	9-9	9-9	7-8	4-6	6-7	6-7	8-9
	6	2	0	8 C-K	10-10	10-10	9-10	10-10	9-9	8-9	8-9	9-10
	3	2	0	8 D-L	10-10	10-10	10-10	10-10	9-9	9-9	9-9	9-10
	3	1	4	9 C-K	10-10	9-10	8-9	8-9	2-5	4-5	3-5	7-8
	6	1	4	9 D-L	10-10	9-10	8-9	8-9	3-5	6-6	5-6	7-8
	6	2	4	10 C-K	9-10	8-9	8-9	8-8	2-4	3-4	3-4	7-7
	3	2	4	10 D-L	9-10	8-9	8-9	8-9	3-3	6-6	5-6	8-8
	3	4	4	11 C-K	9-9	7-9	7-8	7-8	1-3	2-4	2-4	7-7
	6	4	4	11 D-L	9-9	8-9	8-9	8-8	2-2	4-6	4-6	8-8
	6	4	0	12 C-K	9-9	9-10	9-10	10-10	9-9	9-9	9-9	9-9
	3	4	0	12 D-L	9-10	9-10	9-10	10-10	9-9	8-9	8-9	9-9

(Continued)

Table 4 (Continued)

Topsoil Type	Topsoil Thickness In.	Seeding Rate	Fertilizer (Nitrogen) Rate	Item Identification	Ratings 12 June 1950	30 June 1950	11 July 1950	22 July 1950	22 Aug 1950	22 Sept 1950	21 Oct 1950	17 July 1951
Sand Gravel	3	1	1	1 E-M	10-10	9-9	9-9	8-8	4-6	6-6	6-6	7-7
	6	1	1	1 F-N	9-10	8-9	8-9	7-8	3-5	4-4	4-4	7-6
	6	2	1	2 E-M	9-10	8-9	8-9	7-8	4-6	6-6	6-6	9-8
	3	2	1	2 F-N	9-9	7-8	7-8	5-7	2-4	4-5	4-5	7-8
	3	4	1	3 E-M	9-9	8-8	7-8	6-7	4-5	6-6	6-6	9-8
	6	4	1	3 F-N	8-9	7-7	6-7	4-6	2-4	4-5	4-5	7-8
	6	1	0	4 E-M	10-10	9-10	9-9	10-9	9-9	9-9	9-9	9-9
	3	1	0	4 F-N	10-10	9-10	9-9	10-9	9-9	9-9	9-9	9-9
	3	1	2	5 E-M	10-9	9-9	8-8	8-8	4-5	6-6	6-6	8-7
	6	1	2	5 F-N	10-9	8-8	7-8	7-7	2-4	4-5	4-5	8-7
	6	2	2	6 E-M	9-9	9-9	8-8	8-8	4-5	6-6	6-6	7-8
	3	2	2	6 F-N	9-9	7-7	6-6	5-5	2-3	4-5	4-5	8-8
	3	4	2	7 E-M	9-9	9-9	8-7	7-7	4-4	6-6	6-6	8-8
	6	4	2	7 F-N	8-9	7-7	6-6	5-5	2-2	4-5	4-5	8-8
	6	2	0	8 E-M	10-10	10-9	9-9	10-9	9-9	9-9	9-8	9-9
	3	2	0	8 F-N	9-10	9-9	9-9	9-9	9-9	8-9	8-8	9-9
	3	1	4	9 E-M	10-10	9-8	3-6	8-6	2-4	4-6	4-5	7-8
	6	1	4	9 F-N	10-10	6-8	3-6	4-6	2-3	3-4	3-4	7-8
	6	2	4	10 E-M	10-10	8-7	2-6	7-6	2-4	4-6	4-5	7-8
	3	2	4	10 F-N	9-9	6-6	3-6	4-5	2-3	3-4	3-4	8-8
	3	4	4	11 E-M	9-10	9-7	5-6	7-6	2-4	5-5	4-5	6-8
	6	4	4	11 F-N	8-9	7-6	3-6	5-5	2-3	3-4	3-4	8-8
	6	4	0	12 E-M	9-10	9-9	9-9	10-9	9-8	9-8	8-8	9-9
	3	4	0	12 F-N	9-9	9-8	9-8	9-8	9-8	8-8	8-8	9-9
Silty Sand	3	1	1	1 G-O	9-10	8-9	4-8	6-8	4-6	4-4	4-4	6-5
	6	1	1	1 H-P	9-10	10-10	9-9	9-9	4-8	5-5	4-4	7-4
	6	2	1	2 G-O	9-9	7-8	4-8	5-7	4-5	4-4	5-4	6-5
	3	2	1	2 H-P	9-10	9-9	7-9	8-9	5-8	6-6	6-5	7-5
	3	4	1	3 G-O	9-9	7-7	4-7	4-6	3-4	4-4	5-4	6-6
	6	4	1	3 H-P	9-10	8-9	7-9	8-8	5-8	6-6	6-5	7-5
	6	1	0	4 G-O	10-9	9-10	9-9	9-9	9-9	9-9	7-8	9-9
	3	1	0	4 H-P	10-10	10-10	9-10	10-10	9-9	9-9	8-9	9-8
	3	1	2	5 G-O	9-10	7-8	4-8	4-8	2-5	4-4	3-4	6-4
	6	1	2	5 H-P	10-10	10-9	9-9	9-9	4-7	6-5	5-4	7-5
	6	2	2	6 G-O	9-9	5-8	3-8	2-6	2-3	3-4	3-4	6-4
	3	2	2	6 H-P	10-10	10-9	9-9	9-8	6-6	6-5	6-4	7-5
	3	4	2	7 G-O	8-9	2-8	2-7	1-5	2-2	3-4	3-4	7-4
	6	4	2	7 H-P	9-10	8-8	8-8	7-7	4-5	6-5	6-4	8-5
	6	2	0	8 G-O	9-10	8-10	9-9	9-9	9-9	9-9	8-8	9-9
	3	2	0	8 H-P	10-10	9-10	9-10	9-10	9-9	9-9	8-8	9-9
	3	1	4	9 G-O	10-10	7-9	3-8	3-7	1-2	3-3	3-3	7-7
	6	1	4	9 H-P	10-10	8-9	8-9	7-8	2-4	4-4	4-4	7-6
	6	2	4	10 G-O	10-9	4-9	3-8	2-7	1-1	2-3	3-3	7-5
	3	2	4	10 H-P	10-10	8-9	8-9	7-8	2-3	4-5	4-4	8-5
	3	4	4	11 G-O	9-9	4-7	3-7	1-5	1-1	2-2	2-2	7-6
	6	4	4	11 H-P	9-9	7-9	7-9	6-7	2-3	4-3	4-4	8-5
	6	4	0	12 G-O	10-9	7-9	7-9	8-9	9-9	9-9	8-8	8-9
	3	4	0	12 H-P	10-9	9-9	9-9	9-9	9-9	8-9	6-9	9-9

Table 5

TURF PRODUCTION

Plot No. 2 - Impervious Clay Subgrade

Topsoil Type	Topsoil Thickness In.	Seeding Rate	Fertilizer (Nitrogen) Rate	Item Identification	Ratings 12 June 1950	30 June 1950	11 July 1950	22 July 1950	22 Aug 1950	22 Sept 1950	21 Oct 1950	17 July 1951
Impervious Clay	3	1	1	1 A-I	9-10	8-8	9-8	8-8	5-5	5-6	5-6	2-3
	6	1	1	1 B-J	9-9	8-8	9-8	8-7	5-5	6-5	6-5	3-3
	6	2	1	2 A-I	9-9	7-7	8-7	7-6	4-4	3-4	3-4	3-3
	3	2	1	2 B-J	9-9	7-7	8-7	5-5	4-4	3-4	3-4	3-3
	3	4	1	3 A-I	7-9	5-5	6-6	4-5	4-3	2-3	2-3	3-3
	6	4	1	3 B-J	7-8	5-5	6-5	5-5	4-3	2-4	2-4	2-4
	6	1	0	4 A-I	9-10	9-8	9-9	10-9	8-8	7-9	7-9	6-8
	3	1	0	4 B-J	9-10	9-8	9-9	10-9	8-8	7-8	7-8	7-7
	3	1	2	5 A-I	9-9	7-7	7-8	6-7	4-4	3-3	3-4	2-3
	6	1	2	5 B-J	9-9	7-7	7-8	6-6	4-4	3-3	3-3	2-3
	6	2	2	6 A-I	8-9	6-6	6-6	3-4	3-3	1-2	1-2	1-3
	3	2	2	6 B-J	8-9	6-6	6-5	4-4	3-3	2-2	2-2	1-3
	3	4	2	7 A-I	7-9	4-5	4-5	2-4	2-5	1-3	1-3	1-4
	6	4	2	7 B-J	7-8	4-5	4-5	3-4	3-5	1-3	1-3	1-3
	6	2	0	8 A-I	9-10	8-9	8-9	9-9	8-9	5-7	5-5	7-5
	3	2	0	8 B-J	9-10	8-8	9-9	10-9	8-9	7-7	6-6	7-4
	3	1	4	9 A-I	9-9	7-7	7-7	6-5	3-5	3-2	3-2	2-2
	6	1	4	9 B-J	9-9	7-7	7-7	6-5	3-4	3-2	3-2	2-2
	6	2	4	10 A-I	8-9	6-5	4-4	3-3	2-3	2-1	2-1	2-1
	3	2	4	10 B-J	8-8	6-5	5-4	4-4	3-3	3-2	3-2	2-2
	3	4	4	11 A-I	7-7	4-2	3-3	2-2	2-3	2-1	2-1	1-1
	6	4	4	11 B-J	7-6	4-2	4-3	3-3	3-3	3-2	3-2	1-1
	6	4	0	12 A-I	8-8	5-5	4-6	6-6	5-6	4-6	3-4	2-4
	3	4	0	12 B-J	7-6	6-5	4-4	6-4	6-4	5-4	4-2	2-4
Clay Gravel	3	1	1	1 C-K	10-10	9-9	9-8	8-7	5-4	2-2	2-3	1-2
	6	1	1	1 D-L	10-10	9-9	9-8	7-7	3-4	2-2	2-3	1-2
	6	2	1	2 C-K	10-9	9-8	9-7	7-6	3-3	2-2	2-3	1-2
	3	2	1	2 D-L	10-9	9-8	9-7	6-5	3-3	1-2	2-3	1-2
	3	4	1	3 C-K	9-9	8-7	7-6	4-5	3-3	1-2	1-3	1-2
	6	4	1	3 D-L	9-9	8-7	7-6	3-5	2-3	1-2	1-3	1-2
	6	1	0	4 C-K	9-9	9-8	9-9	9-9	8-8	6-7	5-5	7-7
	3	1	0	4 D-L	9-9	9-9	9-9	9-9	7-7	4-6	3-4	7-7
	3	1	2	5 C-K	10-9	9-8	9-9	7-7	3-3	1-2	1-2	1-1
	6	1	2	5 D-L	10-9	9-8	8-8	4-6	2-3	1-2	1-2	1-1
	6	2	2	6 C-K	10-9	8-8	8-7	5-6	2-3	1-2	1-2	1-1
	3	2	2	6 D-L	10-9	8-8	7-7	2-5	1-3	1-2	1-2	1-1
	3	4	2	7 C-K	9-9	7-7	6-6	3-5	2-3	1-2	1-2	1-1
	6	4	2	7 D-L	9-9	7-7	4-6	1-5	1-3	1-2	1-2	1-1
	6	2	0	8 C-K	9-9	8-8	8-8	6-8	7-7	7-5	5-3	2-4
	3	2	0	8 D-L	9-9	8-8	6-8	7-8	4-7	3-5	1-3	2-3
	3	1	4	9 C-K	9-9	8-8	8-8	6-6	3-2	1-1	1-1	1-2
	6	1	4	9 D-L	9-9	8-8	7-8	4-6	2-2	1-1	1-1	1-2
	6	2	4	10 C-K	9-9	7-7	7-7	4-4	2-2	1-1	1-1	1-2
	3	2	4	10 D-L	9-9	6-7	3-7	1-5	1-2	1-1	1-1	1-1
	3	4	4	11 C-K	9-8	[illegible]	3-6	2-4	2-2	1-1	1-1	1-1
	6	4	4	11 D-L	9-9	4-8	2-7	1-6	1-2	1-1	1-1	1-1
	6	4	0	12 C-K	8-8	4-7	3-7	3-6	3-4	2-5	1-3	2-4
	3	4	0	12 D-L	8-8	4-8	3-5	3-6	6-7	2-8	1-7	2-6

(Continued)

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Table 5 (Continued)

Topsoil Type	Topsoil Thickness In.	Seeding Rate	Fertilizer (Nitrogen) Rate	Item Identification	Ratings: 12 June 1950	30 June 1950	11 July 1950	22 July 1950	22 Aug 1950	22 Sept 1950	21 Oct 1950	17 July 1951
Sand Gravel	3	1	1	1 E-M	10-9	9-8	9-6	7-2	4-2	1-1	1-1	1-1
	6	1	1	1 F-N	9-9	8-8	7-6	4-3	2-2	1-1	1-1	1-2
	6	2	1	2 E-M	9-9	9-7	8-4	7-2	3-2	1-1	1-1	1-1
	3	2	1	2 F-N	9-9	8-7	7-6	3-3	2-2	1-1	1-1	1-2
	3	4	1	3 E-M	9-8	7-6	6-4	5-2	3-2	1-1	1-1	1-1
	6	4	1	3 F-N	7-9	6-7	4-6	2-4	3-2	1-1	1-1	1-2
	6	1	0	4 E-M	9-9	9-8	8-7	8-7	7-5	6-5	5-3	6-6
	3	1	0	4 F-N	10-10	9-9	9-9	9-9	7-8	5-7	4-7	7-8
	3	1	2	5 E-M	9-9	8-7	7-6	6-3	2-1	1-1	1-1	1-1
	6	1	2	5 F-N	9-9	7-8	5-8	3-6	2-2	1-1	1-1	1-2
	6	2	2	6 E-M	9-10	7-8	4-5	3-2	2-1	1-1	1-1	1-1
	3	2	2	6 F-N	8-9	4-8	2-6	2-4	2-2	1-1	1-1	1-1
	3	4	2	7 E-M	9-9	6-6	4-3	4-1	2-1	1-1	1-1	1-1
	6	4	2	7 F-N	7-9	2-5	2-3	1-2	2-1	1-1	1-1	1-1
	6	2	0	8 E-M	10-10	9-8	7-8	8-6	7-4	5-2	4-1	2-2
	3	2	0	8 F-N	9-9	8-8	7-9	7-7	5-5	5-2	3-2	3-2
	3	1	4	9 E-M	10-10	9-8	7-7	5-2	2-1	1-1	1-1	1-1
	6	1	4	9 F-N	9-9	6-8	4-8	2-3	2-2	1-1	1-1	1-1
	6	2	4	10 E-M	9-10	9-6	6-2	3-1	2-1	1-1	1-1	1-1
	3	2	4	10 F-N	9-9	7-6	2-3	4-2	2-2	1-1	1-1	1-1
	3	4	4	11 E-M	9-9	7-5	4-2	2-1	2-1	1-1	1-1	1-1
	6	4	4	11 F-N	9-9	4-5	3-3	1-2	2-2	1-1	1-1	1-1
	6	4	0	12 E-M	9-9	8-6	5-3	7-3	6-3	5-2	4-1	4-3
	3	4	0	12 F-N	8-9	4-6	3-5	3-5	3-5	2-4	1-3	3-5
Silty Sand	3	1	1	1 G-O	9-9	8-8	7-6	5-3	1-1	1-1	1-1	1-2
	6	1	1	1 H-P	10-9	8-8	7-6	4-3	1-1	1-1	1-1	1-2
	6	2	1	2 G-O	9-9	7-6	6-5	3-3	1-1	1-1	1-1	1-2
	3	2	1	2 H-P	10-9	7-6	7-5	2-3	1-1	1-1	1-1	1-2
	3	4	1	3 G-O	8-8	5-6	4-4	2-2	1-1	1-1	1-1	1-2
	6	4	1	3 H-P	9-8	6-6	4-5	1-2	1-1	1-1	1-1	1-2
	6	1	0	4 G-O	9-10	8-8	8-8	8-8	7-6	5-5	4-4	7-6
	3	1	0	4 H-P	10-9	9-7	8-6	7-5	5-4	4-3	2-2	5-4
	3	1	2	5 G-O	8-9	6-6	4-4	1-1	1-1	1-1	1-1	1-1
	6	1	2	5 H-P	9-9	7-6	4-4	1-3	1-1	1-1	1-1	1-1
	6	2	2	6 G-O	8-8	4-5	2-3	1-1	1-1	1-1	1-1	1-1
	3	2	2	6 H-P	9-9	5-6	2-4	1-2	1-1	1-1	1-1	1-1
	3	4	2	7 G-O	8-7	2-3	1-2	1-1	1-1	1-1	1-1	1-1
	6	4	2	7 H-P	9-9	2-4	1-3	1-1	1-1	1-1	1-1	1-1
	6	2	0	8 G-O	9-7	3-3	2-2	3-2	3-3	2-1	1-1	2-2
	3	2	0	8 H-P	9-9	6-6	4-5	3-4	3-2	2-2	1-2	2-2
	3	1	4	9 G-O	9-9	6-4	3-4	1-1	1-1	1-1	1-1	1-1
	6	1	4	9 H-P	10-10	6-6	3-4	1-2	1-1	1-1	1-1	1-1
	6	2	4	10 G-O	9-9	2-3	1-2	1-1	1-1	1-1	1-1	1-1
	3	2	4	10 H-P	9-10	2-4	1-2	1-1	1-1	1-1	1-1	1-1
	3	4	4	11 G-O	8-8	2-2	1-1	1-1	1-1	1-1	1-1	1-1
	6	4	4	11 H-P	9-10	2-4	1-2	1-1	1-1	1-1	1-1	1-1
	6	4	0	12 G-O	7-6	2-3	1-2	2-3	3-3	2-2	1-2	4-4
	3	4	0	12 H-P	8-9	3-3	2-2	2-4	3-3	2-3	1-3	4-4

Table 6

TURF PRODUCTION

Plot No. 3 - Lean Clay Subgrade

Topsoil Type	Topsoil Thickness In.	Seeding Rate	Fertilizer (Nitrogen) Rate	Item Identification	Ratings 12 June 1950	30 June 1950	11 July 1950	22 July 1950	22 Aug 1950	22 Sept 1950	21 Oct 1950	17 July 1951
Impervious Clay	3	1	1	1 A-I	10-9	9-9	9-8	8-7	4-4	6-4	6-4	2-2
	6	1	1	1 B-J	10-9	9-8	9-8	7-5	5-4	7-5	7-5	4-3
	6	2	1	2 A-I	10-9	8-9	7-7	5-4	4-3	5-5	4-5	3-2
	3	2	1	2 B-J	9-9	7-7	7-6	4-4	4-3	4-4	4-4	3-3
	3	4	1	3 A-I	9-9	7-8	5-6	4-4	3-2	5-4	4-5	2-2
	6	4	1	3 B-J	9-9	6-7	5-6	4-4	5-2	5-4	4-4	3-2
	6	1	0	4 A-I	10-10	10-9	10-9	10-9	9-9	8-9	8-9	7-9
	3	1	0	4 B-J	10-10	9-9	10-9	10-9	9-9	9-9	9-9	8-9
	3	1	2	5 A-I	10-10	8-8	8-7	7-6	3-4	3-3	3-3	2-2
	6	1	2	5 B-J	10-9	7-7	8-7	5-4	4-4	4-3	3-4	3-3
	6	2	2	6 A-I	9-9	7-7	6-5	4-4	2-3	3-2	3-3	2-2
	3	2	2	6 B-J	9-9	7-7	6-6	4-4	3-3	4-2	4-3	3-3
	3	4	2	7 A-I	9-9	7-6	4-5	2-4	2-3	2-3	1-4	2-3
	6	4	2	7 B-J	8-9	5-6	4-6	3-3	3-3	3-3	3-3	3-3
	6	2	0	8 A-I	9-9	8-9	8-9	9-9	9-9	8-9	8-8	6-8
	3	2	0	8 B-J	9-10	8-9	9-9	9-9	9-9	9-9	9-9	7-8
	3	1	4	9 A-I	9-9	7-8	6-6	4-4	3-2	3-3	3-4	2-2
	6	1	4	9 B-J	8-9	6-7	6-4	4-3	3-2	3-2	3-2	3-2
	6	2	4	10 A-I	9-9	6-7	3-3	3-2	1-1	2-2	1-2	2-1
	3	2	4	10 B-J	9-8	6-5	4-3	3-3	2-2	2-1	2-1	3-2
	3	4	4	11 A-I	8-8	5-5	3-3	3-2	2-1	2-1	2-1	2-1
	6	4	4	11 B-J	8-8	5-4	4-3	3-2	2-2	2-1	2-1	3-3
	6	4	0	12 A-I	9-7	7-7	5-8	7-6	6-7	5-6	3-6	3-8
	3	4	0	12 B-J	9-8	8-9	7-8	8-7	7-8	5-6	5-6	4-7
Clay Gravel	3	1	1	1 C-K	10-10	10-9	10-8	9-7	7-3	3-2	3-2	1-1
	6	1	1	1 D-L	10-10	10-9	9-8	7-5	2-3	2-2	2-2	1-1
	6	2	1	2 C-K	10-10	9-9	8-8	7-6	4-3	3-1	3-1	1-1
	3	2	1	2 D-L	10-10	9-9	8-6	4-4	2-3	2-1	2-1	1-1
	3	4	1	3 C-K	10-9	8-9	7-7	7-4	4-2	3-1	2-1	1-1
	6	4	1	3 D-L	10-10	8-8	6-5	4-3	2-2	2-1	2-1	1-1
	6	1	0	4 C-K	10-10	10-10	10-9	10-9	9-9	9-8	9-7	8-8
	3	1	0	4 D-L	10-10	10-9	10-9	10-9	9-9	8-9	8-9	8-9
	3	1	2	5 C-K	10-10	9-9	9-8	8-5	5-3	2-2	2-2	1-1
	6	1	2	5 D-L	10-10	8-9	7-6	2-2	1-2	1-2	1-2	1-1
	6	2	2	6 C-K	10-10	9-9	9-8	8-4	4-2	1-1	1-1	1-1
	3	2	2	6 D-L	10-10	8-6	7-3	2-1	1-1	1-1	1-1	1-1
	3	4	2	7 C-K	10-9	9-8	8-6	6-2	3-1	1-1	1-1	1-1
	6	4	2	7 D-L	10-9	7-4	6-1	2-1	1-1	1-1	1-1	1-1
	6	2	0	8 C-K	10-10	10-10	9-9	10-9	9-7	9-6	9-5	7-7
	3	2	0	8 D-L	10-9	10-10	9-9	9-9	8-7	8-6	7-5	6-7
	3	1	4	9 C-K	10-9	9-9	8-6	5-3	2-1	2-1	1-1	1-1
	6	1	4	9 D-L	10-9	8-8	6-3	2-2	1-1	1-1	1-1	1-1
	6	2	4	10 C-K	10-9	8-7	6-6	3-2	2-1	1-1	1-1	1-1
	3	2	4	10 D-L	10-9	6-6	3-3	1-1	1-1	1-1	1-1	1-1
	3	4	4	11 C-K	10-9	8-7	6-4	3-1	2-1	1-1	1-1	1-1
	6	4	4	11 D-L	10-9	6-5	3-2	1-1	1-1	1-1	1-1	1-1
	6	4	0	12 C-K	10-9	10-9	9-8	9-8	8-6	7-5	7-5	4-6
	3	4	0	12 D-L	10-9	9-9	9-9	9-9	8-9	7-8	7-9	7-9

(Continued)

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Table 6 (Continued)

Topsoil Type	Topsoil Thickness In.	Seeding Rate	Fertilizer (Nitrogen) Rate	Item Identification	Ratings 12 June 1950	30 June 1950	11 July 1950	22 July 1950	22 Aug 1950	22 Sept 1950	21 Oct 1950	17 July 1951
Sand Gravel	3	1	1	1 E-M	10-10	10-8	9-6	7-3	2-2	2-2	2-2	1-1
	6	1	1	1 F-N	10-10	9-8	7-7	4-3	2-2	2-2	2-1	1-1
	6	2	1	2 E-M	10-9	9-8	7-6	6-3	1-1	2-1	2-1	1-1
	3	2	1	2 F-N	10-9	8-8	6-7	3-4	1-1	2-1	2-1	1-1
	3	4	1	3 E-M	10-9	9-8	7-6	5-4	1-1	1-1	1-1	1-1
	6	4	1	3 F-N	10-9	9-8	7-6	4-3	1-1	1-1	1-1	1-1
	6	1	0	4 E-M	10-10	10-9	10-9	9-9	9-8	9-9	8-8	9-8
	3	1	0	4 F-N	10-10	10-10	9-8	9-9	9-5	9-8	8-6	9-7
	3	1	2	5 E-M	10-10	10-9	9-8	9-5	1-2	1-1	1-1	1-1
	6	1	2	5 F-N	10-10	9-8	8-6	7-2	1-1	1-1	1-1	1-1
	6	2	2	6 E-M	10-10	9-8	9-6	6-3	1-1	1-1	1-1	1-1
	3	2	2	6 F-N	10-10	8-8	7-7	4-2	1-1	1-1	1-1	1-1
	3	4	2	7 E-M	9-10	9-8	8-5	6-2	1-1	1-1	1-1	1-1
	6	4	2	7 F-N	9-10	8-8	6-7	4-2	1-1	1-1	1-1	1-1
	6	2	0	8 E-M	10-10	10-9	10-8	10-8	9-7	8-4	7-4	7-7
	3	2	0	8 F-N	10-10	9-9	9-9	9-8	9-7	9-2	7-2	7-7
	3	1	4	9 E-M	10-10	9-8	8-6	6-5	1-2	1-1	1-1	1-1
	6	1	4	9 F-N	10-10	9-8	6-7	4-3	1-1	1-1	1-1	1-1
	6	2	4	10 E-M	10-10	9-8	7-7	3-5	1-1	1-1	1-1	1-1
	3	2	4	10 F-N	10-10	8-8	4-6	2-2	1-1	1-1	1-1	1-1
	3	4	4	11 E-M	10-9	8-8	6-6	2-4	1-1	1-1	1-1	1-1
	6	4	4	11 F-N	10-9	7-8	4-5	2-2	1-1	1-1	1-1	1-1
	6	4	0	12 E-M	10-9	9-8	9-7	9-7	7-7	7-7	7-7	7-8
	3	4	0	12 F-N	10-9	9-10	9-9	9-9	7-9	7-9	7-9	8-8
Silty Sand	3	1	1	1 G-O	10-10	9-8	7-7	7-4	3-1	3-1	4-2	2-1
	6	1	1	1 H-P	10-10	9-8	7-7	4-3	3-1	3-2	4-2	2-1
	6	2	1	2 G-O	9-10	8-8	6-5	6-2	2-1	2-1	3-1	2-1
	3	2	1	2 H-P	10-10	8-8	6-5	4-2	2-1	2-1	3-1	1-1
	3	4	1	3 G-O	9-10	7-8	5-5	4-2	1-1	1-1	2-1	1-1
	6	4	1	3 H-P	10-10	7-7	5-5	3-1	1-1	1-1	1-1	1-1
	6	1	0	4 G-O	10-10	10-10	10-9	10-9	8-6	8-4	6-4	9-6
	3	1	0	4 H-P	10-10	10-10	9-9	9-9	7-5	8-4	7-3	6-9
	3	1	2	5 G-O	10-10	8-8	7-3	3-2	1-1	2-1	2-1	1-1
	6	1	2	5 H-P	10-10	7-6	4-1	3-1	1-1	2-1	2-1	1-1
	6	2	2	6 G-O	9-10	8-8	7-4	2-2	1-1	1-1	1-1	1-1
	3	2	2	6 H-P	10-10	7-6	4-2	1-1	1-1	1-1	1-1	1-1
	3	4	2	7 G-O	9-10	7-8	5-4	1-1	1-1	1-1	1-1	1-1
	6	4	2	7 H-P	9-10	4-7	2-2	1-1	1-1	1-1	1-1	1-1
	6	2	0	8 G-O	10-10	10-10	9-9	9-9	8-5	8-2	6-2	7-6
	3	2	0	8 H-P	10-10	10-9	9-8	9-8	8-4	7-2	6-2	7-5
	3	1	4	9 G-O	10-10	9-7	7-2	3-1	1-1	1-1	1-1	1-1
	6	1	4	9 H-P	10-10	7-6	3-1	1-1	1-1	1-1	1-1	1-1
	6	2	4	10 G-O	9-9	9-7	6-1	3-1	1-1	1-1	1-1	1-1
	3	2	4	10 H-P	10-10	5-5	1-1	1-1	1-1	1-1	1-1	1-1
	3	4	4	11 G-O	9-9	8-6	5-1	3-1	1-1	1-1	1-1	1-1
	6	4	4	11 H-P	9-10	3-3	1-1	1-1	1-1	1-1	1-1	1-1
	6	4	0	12 G-O	9-10	9-10	8-9	8-9	7-9	6-9	6-7	7-8
	3	4	0	12 H-P	9-10	9-10	9-9	8-9	7-9	7-9	7-7	7-8

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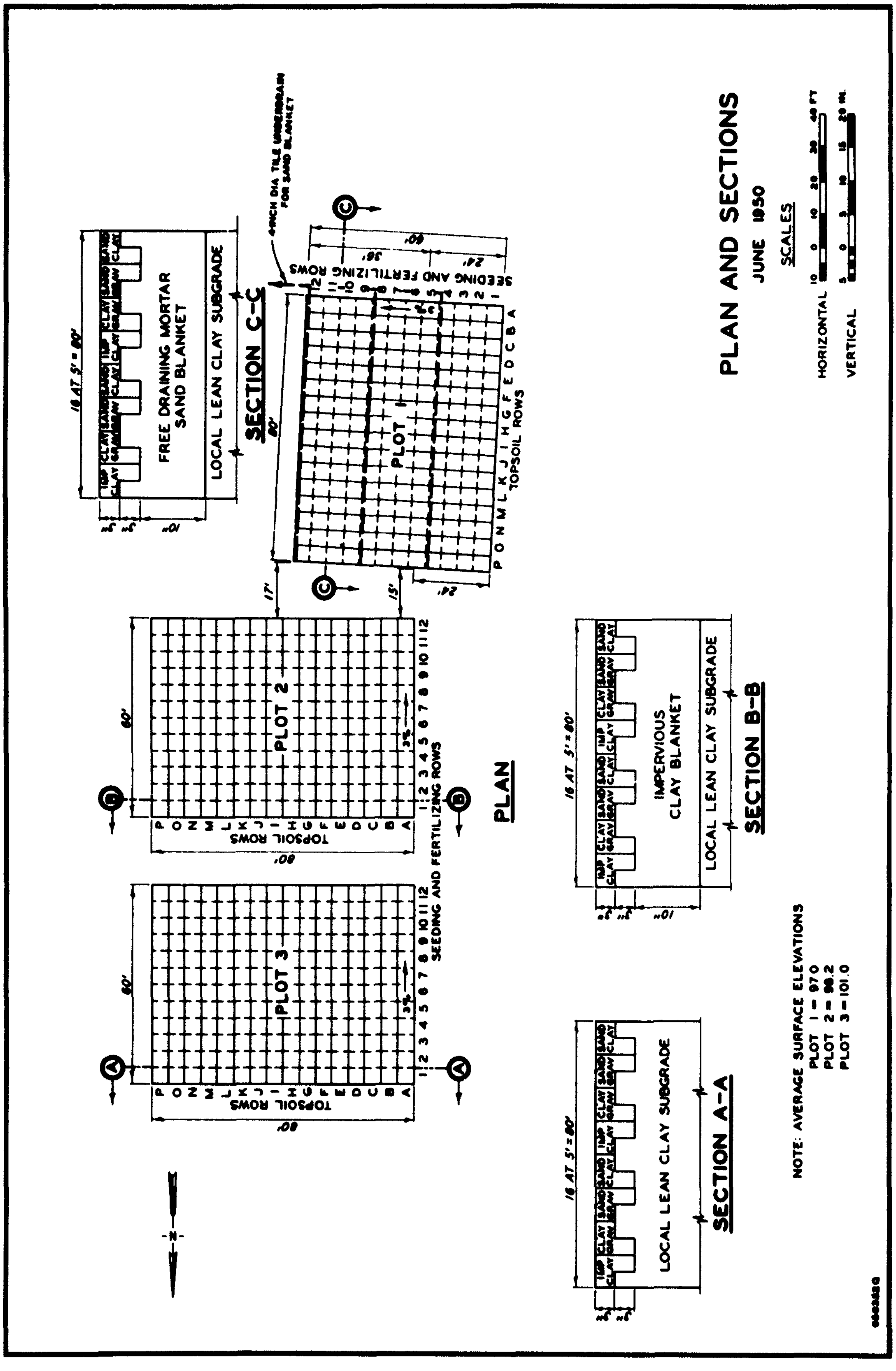
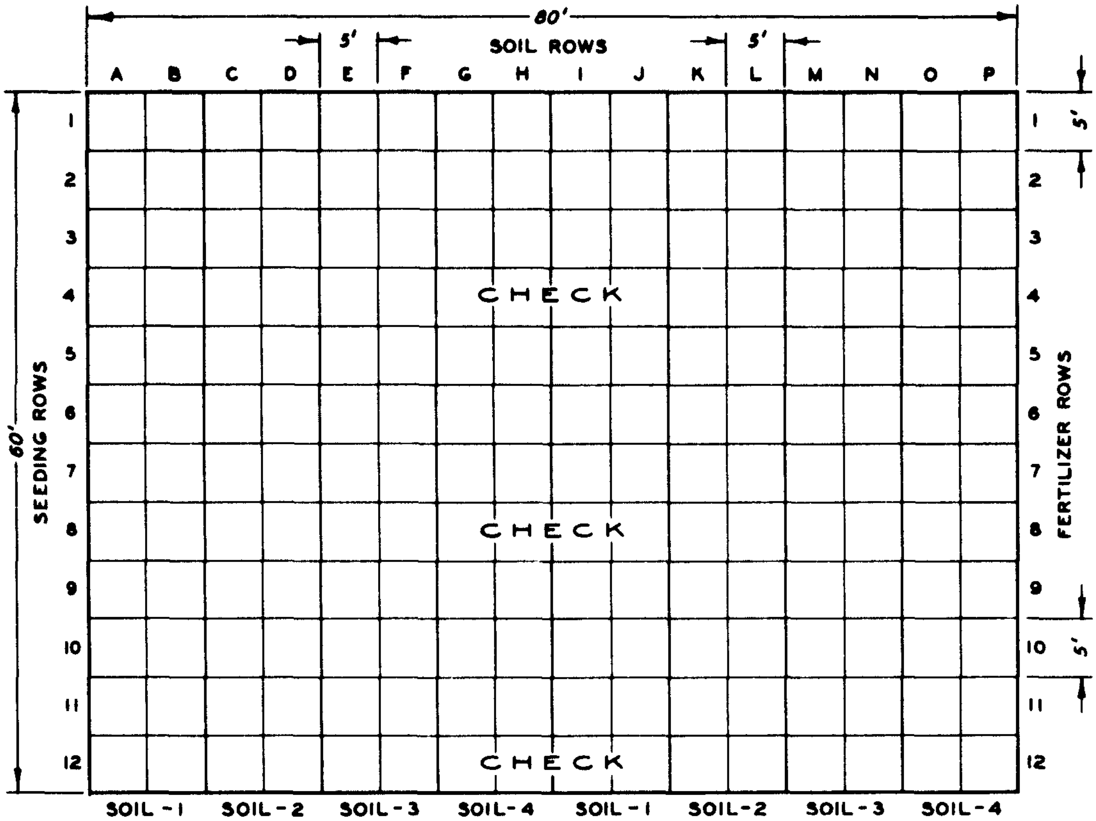
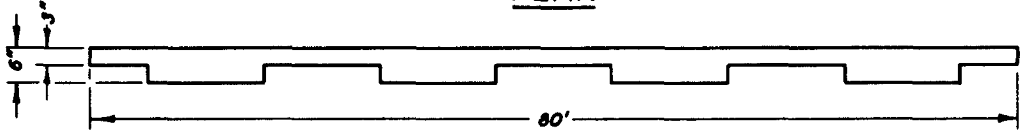
PLATES


PLAN AND SECTIONS
JUNE 1950
SCALES
HORIZONTAL
VERTICAL
PLAN
PLOT 1
PLOT 2
PLOT 3
TOPSOIL ROWS
SEEDING AND FERTILIZING ROWS
SECTION A-A
SECTION B-B
SECTION C-C
LOCAL LEAN CLAY SUBGRADE
IMPERVIOUS CLAY BLANKET
FREE DRAINING MORTAR SAND BLANKET
16 AT 5' = 80'
NOTE: AVERAGE SURFACE ELEVATIONS
PLOT 1 = 97.0
PLOT 2 = 98.2
PLOT 3 = 101.0



PLAN



SECTION

ROW NO.	TREATMENT PER 1000 SQ FT			
	SEED	NITROGEN	P_2O_5	POTASH
1	1 UNIT	1 UNIT	1 UNIT	1 UNIT
2	2 UNITS	1 UNIT	1 UNIT	1 UNIT
3	4 UNITS	1 UNIT	1 UNIT	1 UNIT
4	1 UNIT	0 UNITS	0 UNITS	0 UNITS
5	1 UNIT	2 UNITS	1 UNIT	1 UNIT
6	2 UNITS	2 UNITS	1 UNIT	1 UNIT
7	4 UNITS	2 UNITS	1 UNIT	1 UNIT
8	2 UNITS	0 UNITS	0 UNITS	0 UNITS
9	1 UNIT	4 UNITS	1 UNIT	1 UNIT
10	2 UNITS	4 UNITS	1 UNIT	1 UNIT
11	4 UNITS	4 UNITS	1 UNIT	1 UNIT
12	4 UNITS	0 UNITS	0 UNITS	0 UNITS

FERTILIZER AND SEED SCHEDULE

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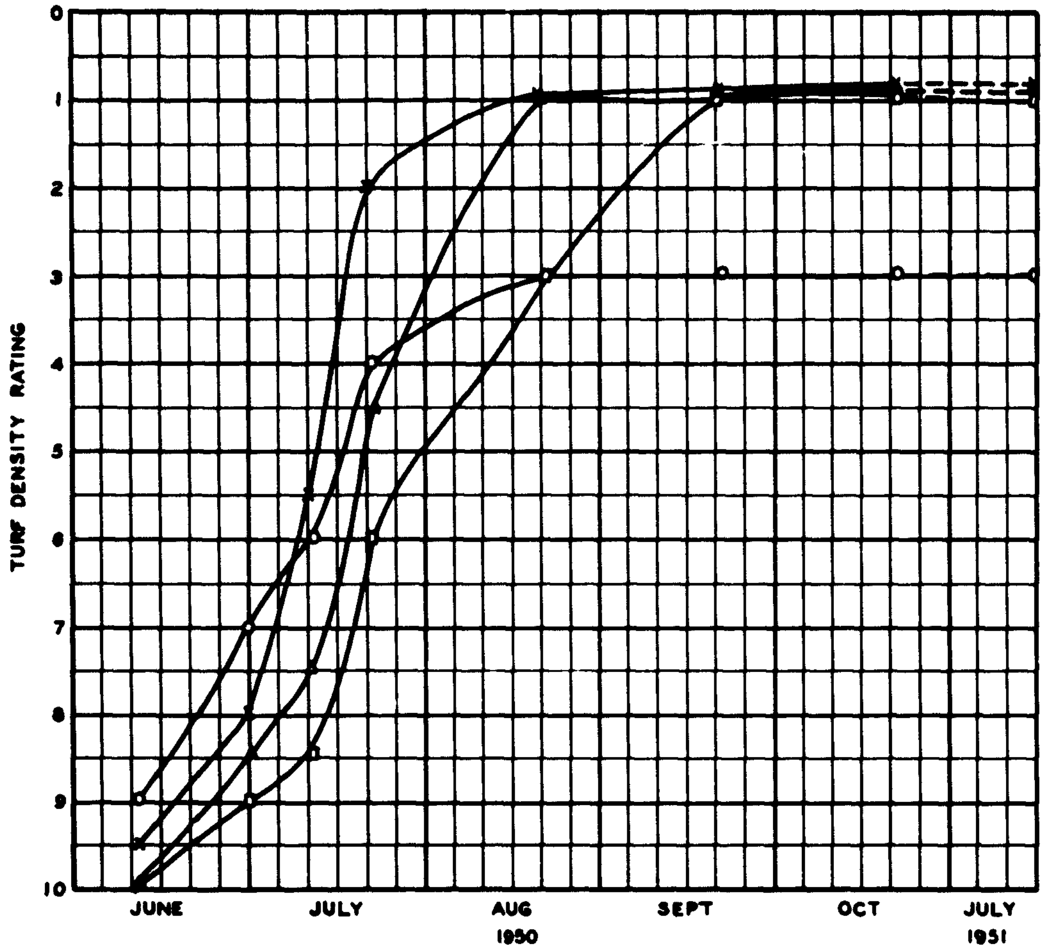
PLATE 2



LEGEND

LEAN CLAY SUBGRADE

6-INCH TOPSOIL THICKNESS
2 UNITS SEED AND FERTILIZER

- CLAY
- CLAY GRAVEL
- SAND GRAVEL
- SILTY SAND

EFFECT OF TOPSOIL TYPE

TIME VS TURF DENSITY

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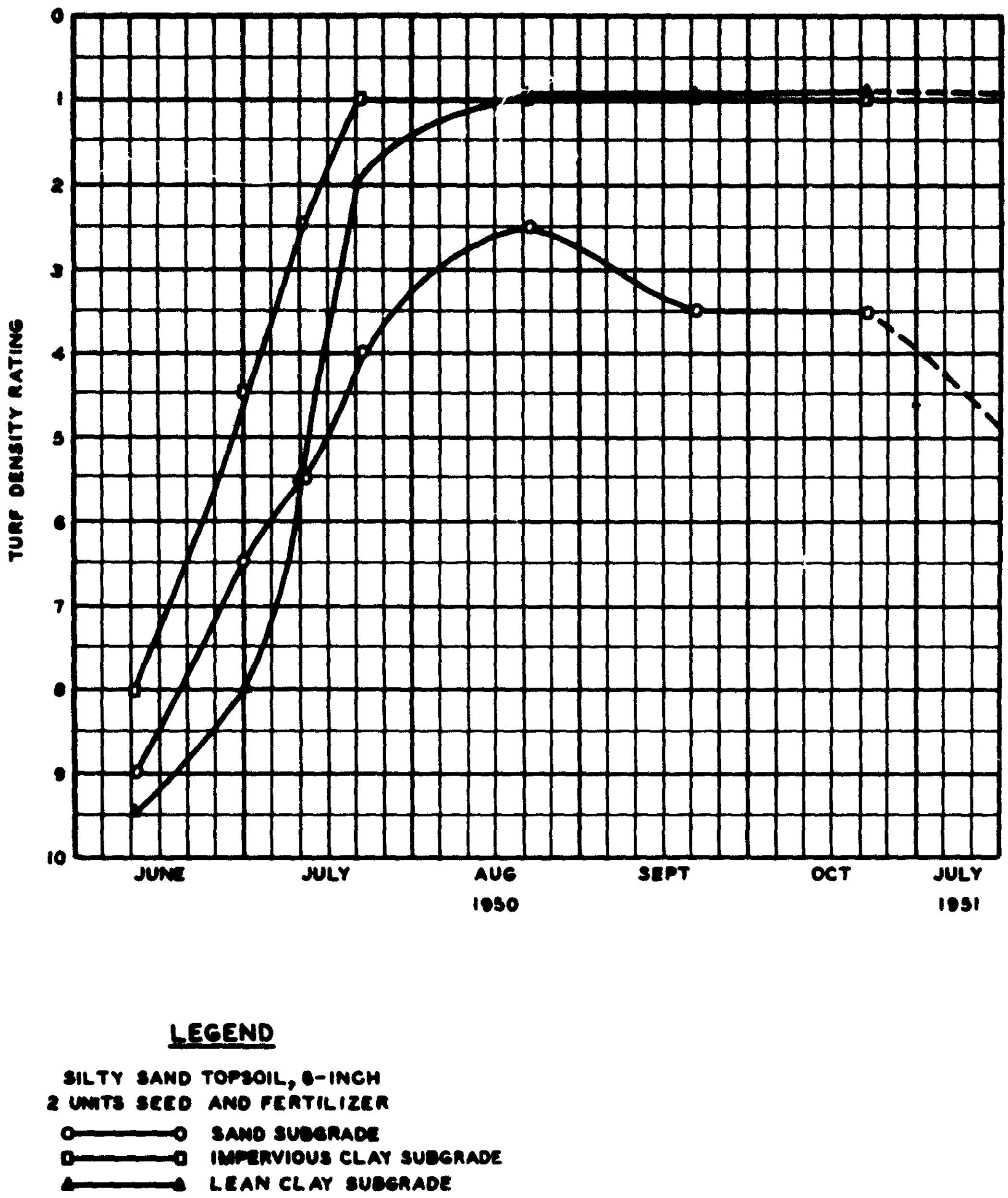

EFFECT OF SUBGRADE TYPE

TIME VS TURF DENSITY

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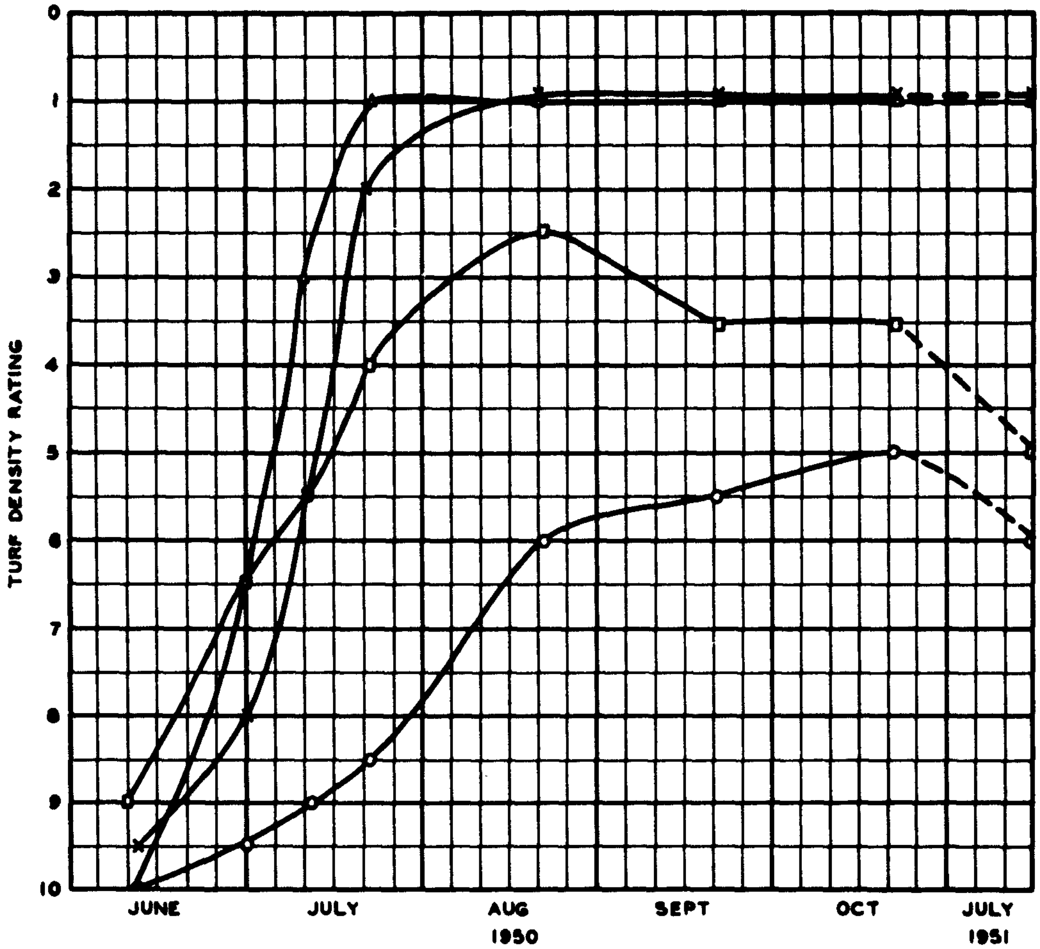
PLATE 4



LEGEND

SILTY SAND TOPSOIL
2 UNITS SEED AND FERTILIZER

O———O 3-INCH THICKNESS SAND SUBGRADE
□———□ 6-INCH THICKNESS SAND SUBGRADE
Δ———Δ 3-INCH THICKNESS LEAN CLAY SUBGRADE
X———X 6-INCH THICKNESS LEAN CLAY SUBGRADE

EFFECT OF TOPSOIL THICKNESS

TIME VS DENSITY

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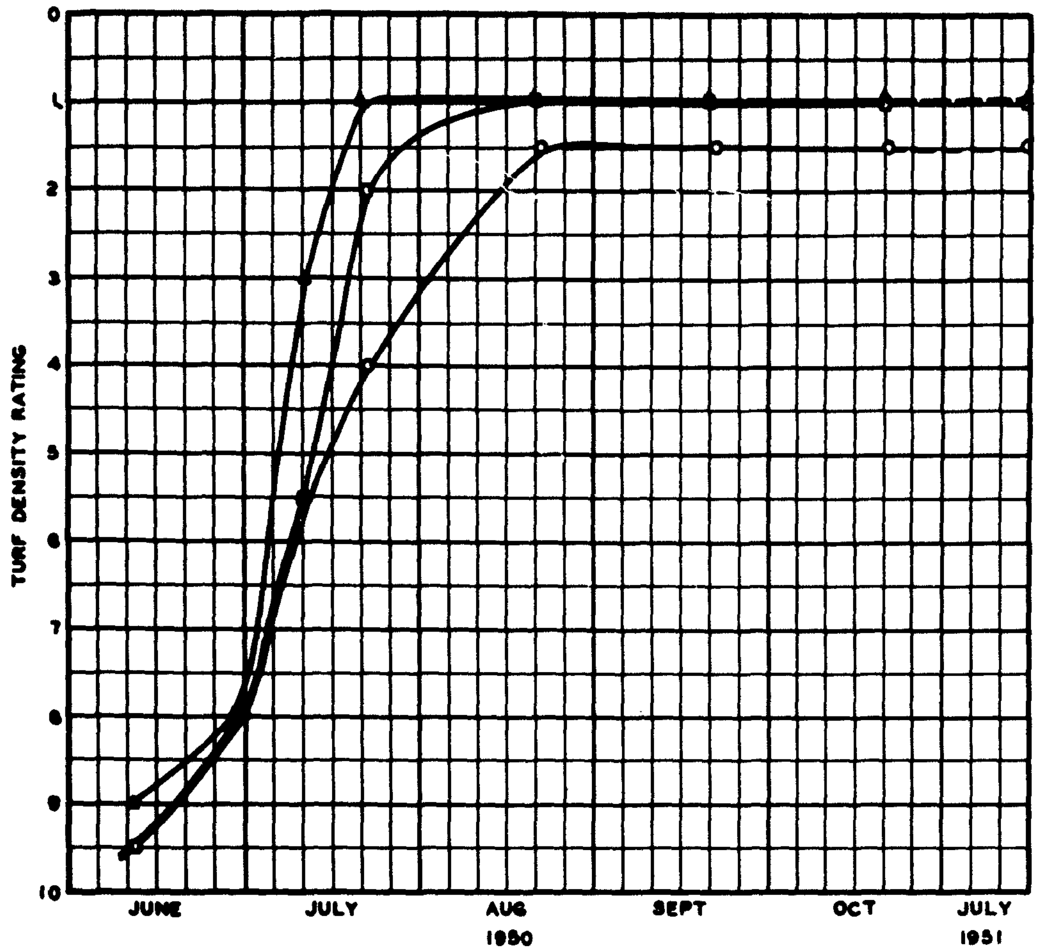


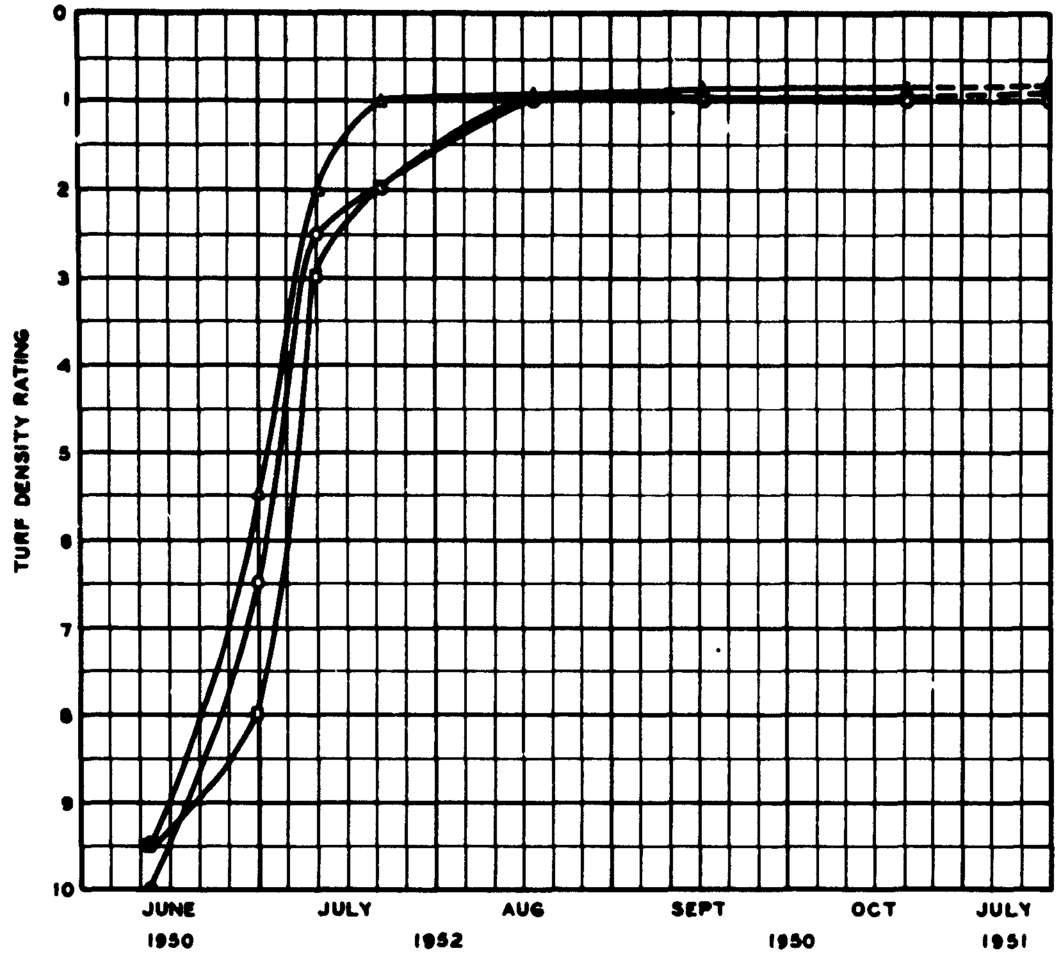
LEGEND

SILTY SAND TOPSOIL, 6-INCH
LEAN CLAY SUBGRADE
2 UNITS OF SEED

- 1 UNIT N
- 2 UNITS N
- 4 UNITS N

EFFECT OF FERTILIZER RATE (N)
TIME VS TURF DENSITY

050382V



LEGEND

SILTY SAND TOPSOIL, 6-INCH
LEAN CLAY SUBGRADE
2 UNITS FERTILIZER

- o———o 1 UNIT SEED
- □———□ 2 UNITS SEED
- △———△ 4 UNITS SEED

EFFECT OF SEEDING RATE

TIME VS TURF DENSITY

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